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Founded by J. A. Nieuwland, C.S.C.

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Flora of Mount Shasta

Wm. Bridge Cooke

Introduction

During four years as Custodian of the Sierra Club's Shasta Alpine Lodge at timberline (Horse Camp) on the southwest side of the mountain one of the ways the writer escaped complete boredom was to collect and preserve as complete a series of Mount Shasta plants as possible. This entailed a number of hikes around the southwest slopes in search of likely places for the finding of plants, and the use of several alternating routes on the regular weekly hikes into Mount Shasta City. The results of ten summer months of collecting are embodied in this report.

Historical

The most comprehensive list of Mount Shasta plants was published in 1899 by C. Hart Merriam in a report on a biological survey of the mountain made in 1898 (13). The Merriam epedition camped for about one month at Wagon Camp. Miss Laura Wilkins collected most of the plants. In addition to local trips in the Wagon Camp vicinity the expedition made two trips around the mountain, one at timberline, and one near the base of the mountain. A few collections made by this expedition have not been duplicated. Most of them have.

In 1896, and again in 1912, Miss Alice Eastwood, of the California Academy of Sciences, made trips to Mount Shasta. On the earlier trip she climbed the mountain, later she came to Horse Camp. Her records have been completely substantiated.

In 1896 H. E. Brown is reported to have made collections on the north side of Mount Shasta between 5000 and 9000 feet. Brown also collected on the southwest slope up to at least 6000 feet. The latter collections, especially topotype material of *Horkelia Brownii* Rydb. (*H. fusca* ssp. *pseudocapitata* of this report), have been duplicated, at least partially. His former collections have not been duplicated. Since the seasons are, in general, earlier on the north side than on the southwest side it is possible that his records of material collected between June 11 and June 16 at the mentioned elevations are valid. We have not had an opportunity to work thoroughly below timberline in this area as yet. The yellow lupine, *Lupinus croceus* Eastwood, is probably the most interesting of this group of Brown plants (8). A recent list of the ferns of the mountain (5) is brought up to date in this report.

Other collectors have visited the mountain from time to time. Some collections, or records, such as those of *Polystichum Lemmonii* (12) and

species reported from Shasta in the looser sense of the term as discussed by Merriam (13) and Wheeler (16) were never made on the mountain. Such material is more typical of the granitic areas of the Klamath Province west of the Sacramento-Shasta Valleys. Some of it, however, occurs in the eastern portions of Siskiyou and Shasta Counties. Most collections have been repeated. Collectors who have visited the mountain include Lemmon, Brewer, Copeland, Jepson, Pringle and others.

General Physiographic Position

Mount Shasta is located in the "lower Cascades" together with Mount Lassen (9). As in the case of other Cascade peaks it is built up of volcanic rocks on a probably Tertiary base (18). Shasta is considered by the latest monographer of its geology the youngest of the Cascade peaks (17). This makes it probably the youngest of the large mountains in continental United States. Together with other factors, involving migration of plants in particular, this may account for the fact that Shasta's vegetation is the poorest in number of species of any large mountain in the United States. To the west of Shasta lies Mount Eddy, highest peak in the granitic Scott Mountains, the eastern edge of the "Klamath Province" which extends roughly from east and north of the headwaters of the Eel River to the Umpqua River in southern Oregon. There has been little, if any, migration from the Klamath Province to Mount Shasta, only two species of limited distribution being common to these two neighboring areas.

To the east of Mount Shasta lie the Warner Mountains on the western edge of the "Great Basin." Between Mount Lassen on the south, Crater Lake (Mount Mazama) on the north, and Mount Shasta, lie great areas — 70 to 100 miles — of Upper Sonoran and Lower Transition zone (in the sense of Merriam) country. Much of this country is volcanic in nature, at least on the surface, and the plant life of the area is similar to that of the Modoc Lava Beds National Monument which lies in the general area. This flora, together with that of Crater Lake National Park, has been adequately treated recently by Applegate (2) (3). We hope to be able to present, in the near future, tables showing comparisons between the various floras of these areas.

Limits for the Following Lists

An arbitrary limit had to be set up as a line below which collecting would not descend. The Merriam report included some material from the McCloud and Sacramento Valleys as well as an occasional exotic of the Scott and Eddy region. I finally decided that I would not collect below a base line on the 4000 foot contour on the U.S.G.S. topographic maps (20) (21) (22). This was done for several reasons. On the west side of the mountain lies the village of Mount Shasta (formerly called Sisson's). There is considerable cultivation in progress in and near the town as many people have their own gardens, and much hay is produced in the flats along the source creeks of the Sacramento River. Weeds from these sources, mostly of Mediterranean and central Asiatic origin have become naturalized along the roads and in the chaparral leading up the mountain. These have no place in the flora of the

mountain and while it has been necessary to include those found above 4000 feet it would only complicate matters to include those found below. A certain amount of migration of chaparral shrubs is still in progress, evidently, up to the areas around the base of the mountain which have long since been lumbered. These shrubs have not become established on the actual slopes of the mountain and are eliminated by the arbitrary line. New plants coming into recent burns are also eliminated when the burns occur below this line. Thus, with the exception of Black Butte and Signal Hill, the area included in this report almost completely coincides with that volcanic area discussed recently by Williams in his report on the geology of Mount Shasta (17) (18).

On the north and northwest side of the mountain lies the valley of the Shasta River, a tributary of the Klamath River. The Shasta Valley is a truly desert valley of the Upper Sonoran Zone and plants of this type are eliminated by the arbitrary line of 4000 feet which lies in the Lower Transition or Chaparral belt. In case these plants have succeeded in migrating up the mountain, as in the case of isolated individuals of *Artemisia tridentata*, they are included here. It is, however, felt at present that the desert conditions of the Shasta Valley flora were produced by migration from, or merely because it is part of, the Great Basin desert of eastern California and Nevada. I should prefer to include in this list only those plants found within the forested areas, but it has been between 50 and 75 years since the lower forests were removed and the chaparral introduced, in its present extended form, through rapid migration into cut-over and burned-over lands. The continuous brush fields around the south, southwest, west and north bases of the mountain now no doubt help to retain at least a portion of the original flora and have themselves become a part of the flora, so they are retained here.

Geology

Mount Shasta is a typical volcano of the Cascade Range. It is considered the youngest of this series of volcanoes. Because of the base elevation of its lowest lavas, as seen near Mount Shasta City and in other exposed places, it is known that it contains the greatest volume of lava (about 80 cubic miles) of any volcano in the series. The mountain is largely composed of various types of andesite lavas. Erosion has not yet played a great part in the disintegration of the mountain. According to Williams (18) little more than a couple of hundred feet have been removed from the summit since its final height was attained. It is possible that it was actively in eruption, that the last cinder storm occurred, in 1786. A number of Pleistocene glaciers existed on the mountain, probably while it was still in the process of erection. Five of these ice masses remain, but are becoming smaller. These include, from north to east to south, the Whitney, Bolam, Hotlum, Wyntun and Konwakiton (or Mud Creek) Glaciers. Larger glaciers once existed as is seen in the large morainal flats on the southwest slopes where there are no active glaciers at present. These are most striking at Horse Camp, and above and below Panther Creek Meadows.

In addition to active glaciers other types of rapid erosion are in progress. At at least four points on the southwest slopes one can trace the path of

avalanches by their remains. On the flats where these occurred the remains of trees which had attained the height of ten to one hundred feet are lying parallel to the course of the avalanche. Large forests were uprooted like so many pickets on a fence. As a result of rapid melting of snow in the late spring an additional type of erosion results. The melting snow sends intermittently great masses of water into creeks through morainal areas. These temporary creeks carry heavy loads of sediment which are deposited along their banks in great carelessness according to the volume of water in the creek. The rapidity of the melting of the glaciers gives good examples of this type of deep V-shaped gully.

For this method of erosion we may best mention the mud flow produced by the Konwakiton Glacier in 1924 (1) and in lesser degree in later years. Due to light snow fall the previous winter the glacier melted near the base more rapidly than usual. The rapid melting dropped a portion of the glacial ice into the canyon below the base of the glacier at the head of Mud Creek. The resulting wall held back the water from melting ice and snow above into a kind of lake, the weight of which finally broke the ice wall. This produced, for several days, a flow of water which included melting ice from the glacier, blocks of lava from the morains near the glacier, debris from the walls of the V-shaped canyon which was further deepened, as well as material from the upper sides of the canyon wall which continually slips by the ton to the floor of the canyon. The only eye-witnesses at the time of the 1924 mud flow reported that it looked as if the whole mountain were coming down the canyon. As the muddy creek reached the more level forest floor below, it fanned out as in flood and left a deposit of mud up to eighteen feet deep in places. The water flowing in the creek, during the following weeks, was one-third lava-sand and glacial mud. The forest surrounding this newly formed alluvial fan was largely destroyed through suffocation and the water rendered unfit for use. Whitney and Bolam glaciers are also subject to similar mud flows during periods of rapid melting, having, at one time, stopped highway and railroad traffic for several days by covering the road beds with debris. Mountainhouse Creek, originating in Hotlum Glacier, has developed for itself a devastated area in the Lodgepole Pine forest on the northeast base of the mountain.

Climate

Knowledge of wind and rainfall is available for Mount Shasta City at 3555 feet above sea level at the base of the mountain (19). Knowledge of prevailing winds has never been accumulated directly on the mountain above that point. In 1930 the California Co-operative Snow Surveys (4) (15) were started in order that flood and irrigation conditions in the Sacramento Valley farming areas could be predicted. To date the records of these surveys, made in January, February, March and April at Horse Camp, are the only precipitation records for points on the mountain above 3555 feet.

The Snow Survey is made once each month during the time of the snow pack. Tools are kept at the Lodge at Horse Camp which is used as a base for operations. The Snow Course is laid out on the morainal flat just below the camp. The data are obtained in the following manner: A metal pipe,

arranged so that a bore of snow can be removed from the pack, is inserted in the snow pack. It is screwed in, in case of layers of ice which have to be penetrated. Upon removal the pipe is weighed. The weight of the snow in the pipe is reduced, on the special balances used, to inches of water content. For accurate precipitation records this has a number of defects. However, it gives a general basis for computation of run off during the melting season. The deepest record is usually that for the month of March. The record is not made of rainfall after melting of snow, and of snow fall which melts from under the pack or evaporates from the top of the pack or falls before the pack begins to form. Rarely more than one-half inch of rain will fall from the time of the last measurement of the pack (end of April) to the first snow fall in late September.

The shallowest pack ever recorded, since 1930, was that of 1934 when, on March 25, there were only 45.2 inches of snow containing 21.6 inches of water. The deepest pack recorded was that of 1938 in which on March 29 there were 220.7 inches of snow containing 120.4 inches of water. The 1939 reports considered the normal seasonal water content of the snow pack as 60.9 inches for the entire season, an average of the previous 9 seasons. The measurement for the course is the result of the average of 32 bores over a major and a minor course. 21 bores on the major course, and 11 bores on the minor course, are spaced 50 feet apart.

Between May and September the prevailing wind direction on the mountain, or rather around the base of the mountain, is considered as north on the east side and south on the west side of the mountain. At Horse Camp, which is situated in a depression between two ridges, our winds seem to be largely down-mountain. Our major storms seem to come from slightly north of west. Clouds, which do not usually produce storms on the southwest slopes, are generally formed on the southeast side of the summit. More clouds form on the south, east and north sides of the summit than on the west and southwest sides, at least during the summer months.

At Mount Shasta City, 3555 feet, average annual rainfall between 1888 and 1930 was 34.31 inches, while the average annual snawfall over the same period was 106.4 inches. At the same point, between 1902 and 1930, the growing season varied from 67 days in 1927 to 250 days in 1908. The average temperature varied, over a period of 42 years, from 33.2 degrees in January to 67.7 degrees in July, with 49 as the average for the year. The average maximum temperature (25 year period) was 62 for the year, 44 in January and 81.4 in July. The average minimum temperature was, over the 25 year period, 34.6 for the year, 23.8 in January and 47.8 in July. The highest recorded temperature, over a 34 year period, was 78 in January and 108 in July. The lowest recorded temperature, over a 34 year period, was -9 in January and 32 in July and August.

Streams

With so much snow on the higher elevations of the mountain it would seem that there would be large streams to take care of the run-off during melting season. This is not the case. Snows melting above 6000 feet are not

carried to the nearest rivers by above ground streams. Mount Shasta is drained on the north by the Shasta Valley, whose main stream is a tributary of the Klamath River. On the south the mountain is drained by the McCloud River, which flows into the Sacramento River in the vicinity of the new Shasta Dam; and on the southwest and west by tributaries of the Sacramento River which enter that river near its sources in the Scott Mountains. On the east the mountain meets several lava ridges which lie to the northeast, and streams flow from the divide between the mountain and the ridge, at just below 6000 feet, into sinks in the Shasta and McCloud Valleys.

There are only two streams which flow from the mountain above the ground surface which meet rivers below. Both enter the McCloud. One is Mud or Elk Creek which originates at the Konwakiton Glacier (locally referred to as the Mud Creek or the McCloud Glacier), the other is Squaw Valley Creek which originates in a series of springs between 8000 and 8500 feet on slopes west of Mud Creek Canyon. Whitney Creek, made up of Inconstance Creek (from Whitney Glacier) and Bolam Creek (from Bolam Glacier), may, during seasons of heavy glacial or snow melting, meet the Shasta River near its source. However, this creek usually sinks and flows underground in the southern end of the Shasta Valley. Mountainhouse and Brewer Creeks, from Hotlum Glacier, Ash Creek from Wyntun Glacier, and Cold Spring Creek, from a spring below Wyntun Glacier, all enter sinks on the east or southeast side of the mountain, from which they probably flow underground to the McCloud River. Panther Creek, which originates in a series of springs at the head of Panther Creek Meadows, flows down through a series of meadows and cascades and sinks a mile or so above Wagon Camp, to which it rarely flows during years of heavy snows, whose springs probably originate in the underground pool into which Panther Creek possibly percolates. Bear Springs and the Municipal Spring at Howard probably result from the underground flow of waters from melting snow along the trail from Horse Camp to the Summit. A number of small springs, which flow from ten to one hundred feet before again sinking into the mountain, exist around the southwest slopes of the mountain. No springs like these have been reported on other slopes at the same above-timberline position. None exist on the northwest and north slopes. At least seven of these springs have been visited. There are a large number of V-shaped valleys around the mountain. Some are deep, others shallow, but, except when snow is melting heavily above, all these valleys are dry.

Life Zones

The life zones of Mount Shasta possibly formed a portion of the bases on which Merriam built his life zone concept. They are described in his report on Shasta (13). In an unpublished paper, which unfortunately was destroyed by the San Francisco fire in 1906, E. B. Copeland explained how such zones could apply to a dry mountain such as Shasta while not to a wet one, with a granitic base, such as Eddy just across the valley from Shasta.

Due to excessive seepage through the very porous lavas of the mountain

and the large number of sinks around its base, the water, to all intents and purposes, which was brought to the mountain in the form of snow, is lost to the plant life. This has caused a near-desert condition to exist. There are only a very few localized outlets for water and these are, for the most part, small and of short length. Thus Hemlock, which seems to require a great amount of water, is absent from most the area where it would normally occur and occurs at discontinuous stations near the source of water. The forest which does exist on the mountain can easily be divided into zones based on the association of species and labeled with the well known Merriam names. For the most part, except on the northeast side of the mountain, these zones remain constant. The zone description given here is sketchy and is subject to revision (5a).

Chaparral Belt.—This occupies the area on the gentler slopes of the mountain below the upper limits of past lumbering. It forms a large green mat around the base of the mountain except at the Lodgepole Pine forest on the northeast side. If a great forest once grew in this area (14), little if any of that forest is left unless one can reconstruct it in imagination from the isolated individuals of *Abies concolor, Libocedrus decurrens, Pinus ponderosa, P. attenuata* and *P. Lambertiana* which are found throughout the brush fields except at most unfavorable locations. Gradually the Forest Service is brushing out areas of this Chaparral Belt and is planting Pine seedlings in place of the brush. It will be of interest to watch these experiments. The chaparral is dominated by *Arctostaphylos patula* and *Ceanothus velutinus*. Other species may be locally present and even locally dominant. These include: *Castanopsis chrysophylla* and *C. sempervirens, Ceanothus prostratus, C. divaricatus* and *C. cordulatus, Pachystima myrsinites, Amelanchier alnifolia, Prunus demisa, P. emarginata* and *P. subcordata, Purshia tridentata, Chrysothamnus nauseosus* var. *occidentalis, C. Bloomeri* var. *angustatus*, and others. According to Cooper (6) this type of Chaparral is considered successional rather than climax.

Upper Transition Zone.—On the assumption that the Craparral Belt is part of the Transition Zone, that part of this zone in which the normal Sierran transition forest stands should be called the Upper Transition Zone. This forest includes *Pinus ponderosa, P. Lambertiana, P. attenuata, Pseudotsuga taxifolia, Abies concolor* and *Libocedrus decurrens*. Where logging has left openings in the forest the chaparral has invaded it. In fact, the chaparral extends up barren slopes which either could not have been forested or on which the forest has long since been burned off, at least up to 7500 feet. *Abies magnifica* var. *shastensis* extends downward into the Upper Transition Zone, but does not extend to the lower altitudinal limits of the zone. *Pinus monticola*, normally an unimportant tree in the Canadian Zone, extends downward into this zone, at least in Mud Creek Canyon, to 5000 feet. *Pinus contorta* var. *Murrayana* occupies most of the area of this zone on the northeast side of the mountain along the old military road. *Pinus ponderosa* var. *Jeffreyi* occurs in the upper edge of the zone. This zone can be said to extend from as low as 4500 feet on some ridges and in some protected places. Occasional second growth stands extend the range of it more and

more. It usually ends at its lower level at 5000 feet. The limits of the belt depend on the past availability of trees for logging purposes.

Canadian Zone.—This is strictly defined on the southwest, south, west and north slopes, at least, by the almost exclusive presence of *Abies magnifica* var. *shastensis*. *Abies concolor* may enter at the base and penetrate as high as 6000 feet. *Pinus albicaulis* may descend in it to 7000 feet. Normally, the Shasta Red Fir marks the upper limit of timberline so that the Hudsonian Zone lies mostly above timberline. *Tsuga Mertensiana* occurs in an isolated clump on the northwest slope of Shastina just below timberline. It also forms a fairly large stand on the borders of the upper and middle Panther Creek Meadows. However, it is around the upper and middle portions of Squaw Valley Meadows that one finds Mountain or Black Hemlock in abundance. At this point and around Red Butte to the divide between the Gray Butte plug domes the forest is made up largely of Hemlock. Fir is present here but by no means dominant. It is interesting to cross the above mentioned saddle on Gray Butte. On the east slope the forest is largely of Hemlock, on the west it is largely of Shasta Fir. Hemlock also extends east from Squaw Valley Creek to the west bank of Mud Creek Canyon on the forested slopes of which it is an occasional member of the forest.

On the west slope of the mountain a few isolated individuals of *Pinus monticola* are present in the Canadian Zone. However, if one should go up to 7000 feet on the north slope between Bolam Creek and Inconstance Creek, near Bolam Creek, he should find, in the Canadian Zone, the following assortment of conifers: *Pinus ponderosa* (var. *Jeffreyi?*), *P. monticola*, *P. contorta* var. *Murrayana*, *P. albicaulis*, *Abies concolor*, *A. magnifica* var. *shastensis*, and *Juniperus communis* var. *montana*. The fourth and last normally occur only in the Hudsonian Zone, while the second and sixth are in what might be called their true Shasta zonal position. The understory, aside from the Juniper, consists, at this point, exclusively of *Ribes cereum*, and *Castanopsis sempervirens*. *Pinus monticola* also occurs in the Canadian Zone on the banks of Mud Creek Canyon where it extends from timberline to chaparral.

Hudsonian Zone.—This zone lies mostly above timberline which varies from 8000 to 8500 feet. The Hudsonian Zone will have its upper limits at from 8200 to 9500 feet depending on whether its location is on valleys or ridges. On the south and east slopes of ridges one finds dwarf *Pinus albicaulis* specimens as high up as 9500 feet and as tall as six inches. The species will also inhabit flats and knobs between ridges but it will not advance as far up the flat or knob as up the edge of the ridge. Together with White-Bark Pine on the lower portions of its range above timberline one will find dwarf specimens of *Abies magnifica* var. *shastensis* and *Tsuga Mertensiana*. On some ridges an occasional individual of *Abies concolor* has been noted in this dwarf forest.

On the north side of Shastina, near the head of the large recent lava flow which originated in that vicinity, is a large semi-erect forest of *Pinus albicaulis*. The forest has been heavily attacked by *Arceuthobium campylopodum* f.

cyanocarpum. This dwarf mistletoe has caused witches brooms of the trees, producing a very ghostly effect. The type of broom is that which enlarges the base of the branch, kills the branch at that point, and leaves a whorl of cone-like enlarged branch bases on the trunk. The mistletoe, whose flowering branches average a half inch or less in height, becomes evident to the eye only on young twigs. A large number of trees have been affected in this manner and killed, and a large number of young trees are infected.

Arctic-Alpine Zone.—It is doubted by some whether or not a true Arctic-Alpine Zone exists in California. Patches of Alpine vegetation may occur locally in the Sierras according to the interpretation of the regional monographer. If such a zone exists on Mount Shasta it is difficult to define. Its upper limits, of course, are the upper limits of plant life on the mountain, which lie between 12,000 and 13,000 feet, the mountain being 14,161 feet high. If one should set a lower limit for the zone there are several localized patches of plants which would have to be considered. One can set up the zone after the manner of Merriam as being above the limits of *Pinus albicaulis*, the highest growing tree species on the mountain, and include some of the localized patches which occur below Merriam's timberline but in exposed places. On the basis of association of plants the zone could be based on *Poa epilis* and *Carex phaeocephala*, the only plants on the mountain which occur strictly above the limits of tree growth.

A number of plants are of high altitude distribution. Except for the grass and sedge mentioned above all occur below the upper limits of *Pinus albicaulis*, sometimes in association with that Pine, in other places in locations of apparently definite subalpine climatic conditions. For instance, on the north side of Red Butte, about half way up the north face of the butte, lies a patch of vegetation which includes *Polemonium shastense*, *Saxifraga Tolmiei*, *Oxyria digyna* and *Silene Watsonii*. On the south face of a red ridge to the west of and just above Panther Creek Meadows is a small colony of *Draba Breweri*, formerly thought to occur only at 13,000 feet on the ridge between Wyntun and Konwakiton Glaciers. On the west bank of Mud Creek Canyon at 9500 feet, but below the limits of White Bark Pine, is another subalpine colony which includes *Achillea lanulosa* var. *alpicola*, *Erigeron compositus* var. *multifidus*, *Senecio oreopolus*, *Silene Watsonii*, *Polemonium shastense*, and others.

A number of the boreal springs, mentioned in an earlier paragraph, may be thought of as subalpine. With several of these it is difficult to say whether or not they are above the limits of the White-Bark Pines. In one of these in The South Gate *Potentilla flabellifolia* grows. It is found nowhere else on the mountain. Thus these scatered communities make strict zonal definition above climatic timberline difficult.

Timberline.—Merriam considered this phase of the problem to be represented by the highest limits of tree life. That is, if *Pinus albicaulis* grows along a ridge, the highest specimen on that ridge, even if it be a mat only a few inches in height, is the upper limit of timberline on that ridge. We prefer to use timberline in the economic or climatic sense of the term. In this case timberline includes the upper limits of upright tree growth, roughly coinci-

dental with the boundary between the Canadian and Hudsonian zones. Thus timberline becomes a belt rather than a definite line. This is the sense of the term in which the Forest Service uses it and in which it is described by Hopkins in "Bioclimatics" (11).

Sources of the Flora

Enough of the plants on the mountain have been compared in distribution with other areas that we may roughly say that the flora on Mount Shasta has originated from both the north and the south. Most of the plants on the mountain are fairly common. A few are of rather local and limited distribution.

So far as we have been able to discover there are no endemic plants on Mount Shasta. *Polemonium shastense*, which was discovered by E. B. Copeland and named by Miss Eastwood, and *Arnica viscosa*, collected near Horse Camp, which was named by Asa Gray, were thought, until recently (3), to be endemic to Mount Shasta.

To our knowledge, at least two plants of limited distribution are common to both Mount Shasta and the Klamath Province. These are *Campanula Wilkinsiana* Greene, collected by Miss Wilkins of the Merriam Expedition, which has been found by Miss Eastwood at Canyon Lakes in the Trinity-Salmon Alps, and a species of *Juncus*, collected first by John Thomas Howell in the Scott and Marble Mountains and more recently on Mount Shasta by the writer. Dr. Hermann is publishing this Rush in a forthcoming paper.

It is of interest to note that in addition to *Arnica viscosa* Gray and *Polemonium shastense* Eastwood being common only to Mount Shasta and Crater Lake, *Lupinus obtusilobus* Heller is common only to Mount Shasta, Mount Lassen and Mount Pleasant (in Plumas Co.).

A list, too lengthy for inclusion here, is in preparation in which a comparison is being made relating the Mount Shasta flora to the floras of the Cascades, Sierras, the Great Basin and the Klamath Province. Suffice it to say that of the 200 plants listed for the Modoc Lava Beds National Monument (7), in northeastern Siskiyou County, 86 are known on Mount Shasta. in central Siskiyou County; and of the 570 plants listed for Crater Lake National Park (3), in the southern Oregon Cascades, 232 are found on Mount Shasta, in the northern California Cascades. No data are available as yet for Mount Lassen.

Nearly 425 species, varieties, subspecies and forms are included in the following list. These are divided into 59 families, 211 genera, 402 species. 17 forms, varieties and subspecies; and include 15 trees, 55 shrubs and vines, and 339 herbaceous plants and 13 ferns.

Place Names on Mount Shasta

Due to the fact that few people have climbed more than the Summit Trail and the trails leading to the foot of the Summit Trail at Horse Camp. there has been little need for names for ridges and valleys. There are a few

locations on the mountain with standardized names. For other colletcion locations we have had to manufacture names or place the location with reference to established named locations. The accompanying map, prepared by Thomas Cobbe, will assist the reader in understanding the general area.

A trail for hikers and horses leads from Mount Shasta City directly to the Shasta Alpine Lodge at Horse Camp. This is known as the Sisson Southern Trail. A wagon trail once led from Sisson to Wagon Camp where it terminated and a hiking or horse trail led from there to Horse Camp (where horses were tethered by climbers). This trail is referred to as the Wagon Camp-Horse Camp Trail. The two large Canadian Zone meadows, the one along Panther Creek, the other along Squaw Valley Creek, have long been known. Between them lie Gray Butte to the west and Red Butte to the east. Between Gray Butte and the mountain is a pass known as The South Gate. The deep canyon on the northwest side of Shastina was named by Merriam for Diller, the first monographer of the geology of Shasta. I shall refer to the creek south of Horse Camp as Horse Camp Creek; to the ridges between Horse Camp and Panther Creek Meadows as the South Ridges, including the two red ridges west of and above Panther Creek; and to the ridges between Horse Camp and Cascade Gulch, the valley beginning in the amphitheater between Shasta and Shastina on the west slope, as the North Ridges. Bear Springs lie along the Wagon Camp road at 5000 feet. Howard lies at 4000 feet along the same road at the point where the road crosses the McCloud River Railroad. The Municipal Spring is a spring outlet up a small creek from Howard. Mount Shasta City obtains its water supply from this spring. The John Everett Memorial Highway extends from Mount Shasta City up Mount Shasta through the chaparral to MacBride Springs, at 5000 feet, and to Panther Creek Meadows at 7500 feet. MacBride Springs lie at the foot of a recent lava flow just north of Cascade Gulch on the south side of which the Sisson Southern Trail descends the mountain. Widow Springs are on the southeast slope of the mountain at about 5000 feet in a National Forest Public Camp Ground. The Forest Service is developing a Public Camp Ground at Panther Creek Meadows at the end of the Memorial Highway. Mud Creek Canyon is on the south slope and terminates at the Mud Creek Dam below which is the Mud Creek devasted area east of the lumber town of McCloud. The old military highway now serves as a round-the-mountain road which begins at Morrison on the Weed-Klamath Falls Highway (U.S. 97) and ends in McCloud on the Shasta-Lassen Highway (Calif. 89).

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Dr. W. R. Maxon, Smithsonian Institute—*Polystichum*
Dr. T. M. C. Taylor, University of Toronto—*Woodsia*
Dr. Jason R. Swallen, Bureau of Plant Industry—*Gramineae*
Mr. J. W. Stacey, California Academy of Sciences—*Carex*
Dr. H. K. Svenson, Brooklyn Botanic Garden—*Eleocharis*
Dr. F. J. Hermann, Bureau of Plant Industry—*Juncaceae*
Mr. Robert Hoover, Berkeley, Calif.—*Calliprora*
Miss Susan Stokes, Berkeley, Calif.—*Eriogonum*
Mr. Reed Rollins, Gray Herbarium—*Cruciferae*—except
Dr. C. Leo Hitchcock, University of Washington—*Draba*—and
Mr. G. B. Rossbach, Dudley Herbarium—*Erysimum*
Dr. David D. Keck, Carnegie Institution of Washington, Stanford University—*Achillea, Artemisia, Horkelia, Madia, Orthocarpus, Pentstemon, Potentilla.*
Dr. Charles Piper Smith, Saratoga, Calif.—*Lupinus*
Dr. Philip Munz, Pomona College—*Epilobium*
Dr. I. M. Johnston, Arnold Arboretum—*Boraginaceae*
Dr. H. L. Mason, University of California—*Polemoniaceae*
Mr. J. T. Howell, California Academy of Sciences—*Phacelia*
Dr. C. C. Epling, University of California at Los Angeles—*Stachys*
Miss Alice Eastwood, California Academy of Sciences—*Castilleja*
Dr. M. L. Fernald, Gray Herbarium—*Veronica*
Dr. G. N. Jones, University of Illinois—*Symphoricarpos*
Mr. Basset Maguire, Utah State Agricaultural College—*Arnica*
Dr. Palmer Stockwell, Calif. Forest Exp. Station—*Chaenactis*
Dr. S. F. Blake, Bureau of Plant Industry—*Compositae* (except genera listed above.)

Key to Families

1. Plants bearing spores in various types of sori and sporangia 2
1. Plants bearing seeds in open cones or closed ovaries 4
2. Stems jointed ..... 1. *Equisetaceae*
2. Stems not jointed 3
3. Sporangia borne on spikes ..... 2. *Ophioglossaceae*
3. Sporangia borne on the backs of leaves ..... 3. *Polypodiaceae*
4. Ovules borne on open scales in cones 5
4. Ovules borne in closed ovaries 6
5. Scales of cones produced in compact spiral series ..... 4. *Pinaceae*
5. Scales of cones in pairs, cones becoming dry or fleshy, berry-like ..... 5. *Cupressaceae*
6. Flower parts in 3's or reduced, seeds producing one primary leaf 7
6. Flower parts commonly in 4's or 5's, seeds producing two primary leaves 12
7. Perianth parts reduced, sepals and petals lacking or present as variously modified scales 8
7. Perianth parts not reduced although they may appear inconspicuous 9
8. Perianth, if present, found as minute scales at the base of the flower, pistil and stamens surrounded by a complex system of bracts and bractlets ..... 6. *Gramineae*
8. Perianth usually absent, present in one genus in which it appears as a series of slender, awned, hair-like structures; ovary and achene usually enclosed in a sac-like bract ..... 7. *Cyperaceae*
9. Perianth chaff-like, inconspicuous ..... 8. *Juncaceae*
9. Perianth usually showy 10
10. Ovary superior ..... 9. *Liliaceae*
10. Ovary inferior 11
11. Stamens 3 or 6 ..... 10. *Iridaceae*
11. Stamens 1 or 2, united in a column around the style ..... 11. *Orchidaceae*

12. Petals absent 13
12. Petals present 22
13. Trees or shrubs, at least some of the flowers in catkins 14
13. Herbs, trees or shrubs, flowers not in catkins 16
14. Plants dioecious, both kinds of flowers in catkins ..... 12. *Salicaceae*
14. Plants monoecious 15
15. Both pistillate and staminate flowers in catkins ..... 13. *Betulaceae*
15. Only staminate flowers occurring in catkins ..... 14. *Fagaceae*
16. Plants parasitic on branches of trees ..... 15. *Loranthaceae*
16. Plants not parasitic 17
17. Ovary superior, not united with receptacle or calyx 18
17. Ovary inferior, at least partially united with the receptacle or calyx ..... 16. *Aristolochiaceae*
18. Leaves with scarious, sheathing stipules ..... 17. *Polygonaceae*
18. Leaves without such stipules 19
19. Calyx none, 1 pistillate and several reduced staminate flowers enclosed in a more or less showy calyx-like involucre ..... 33. *Euphorbiaceae*
19. Calyx present, flowers not as above 20
20. Pistils generally several (1 in *Actaea*), unicarpellate ..... 22. *Ranunculaceae*
20. Pistil 1, ovary 1-loculed, pluricarpellate 21
21. Plants not scurfy ..... 18. *Amaranthaceae*
21. Plants mostly scurfy ..... 19. *Chenopodiaceae*
22. Petals mostly free from each other 23
22. Petals more or less united 44
23. Ovary superior 24
23. Ovary inferior 40
24. Stamens not borne on a disk or enlarged receptacle 25
24. Stamens borne on a disk or an enlarged receptacle 37
25. Pistil simple, 1 to many 26
25. Pistil 1, compound 28
26. Pistil 1, flowers irregular, papilionaceous ..... 29. *Leguminosae*
26. Pistils 1 or none, flowers, if irregular, not papilionaceous 27
27. Carpels not united at base, plants not succulent ..... 22. *Ranunculaceae*
27. Carpels partially united at base, plants fleshy, succulent ..... 26. *Crassulaceae*
28. Insectivorous bog plants with basal rosettes of glandular hairy leaves ..... 25. *Droseraceae*
28. Not insectivorous bog plants 29
29. Carpels 5 to many, splitting apart in fruit 30
29. Carpels remaining united in fruit 31
30. Stamens not united ..... 31. *Geraniaceae*
30. Stamens united by the filaments into a tube ..... 37. *Malvaceae*
31. Anthers opening by pores; or if by slits, plants saprophytic ..... 44. *Ericaceae*
31. Anthers not opening by pores, plants not saprophytic 32
32. Sepals 5 33
32. Sepals 2 or 4 36
33. Placentae basal or free-central ..... 21. *Caryophyllaceae*
33. Placentae parietal 34
34. Flowers irregular, leaves not glandular dotted ..... 39. *Violaceae*
34. Flowers regular, leaves with or without glandular dots 35
35. Leaves linear, alternate, not glandular dotted, ovaries with false partitions ..... 30. *Linaceae*
35. Leaves not linear, opposite, glandular dotted, ovaries without false partitions ..... 38. *Hypericaceae*
36. Sepals 2, petals and stamens usually 5, placentae basal or free-central ..... 20. *Portulacaceae*
36. Sepals 4, petals 4, stamens 6, placentae parietal ..... 24. *Cruciferae*
37. Stamens of the same number and opposite the petals ..... 36. *Rhamnaceae*
37. Stamens alternate with the petals if of the same number 38

38. Leaves alternate, pistils many, simple ..... 28. *Rosaceae*
38. Leaves opposite, pistil 1, compound 39
39. Fruit a winged samara ..... 35. *Aceraceae*
39. Fruit a 2-loculed capsule ..... 34. *Celastraceae*
40. Flowers in umbels, petals and stamens 5 ..... 42. *Umbelliferae*
40. Flowers not in umbels 41
41. Flower parts mostly in 5's, styles 2-5 ..... 27. *Saxifragaceae*
41. Flower parts mostly in 2's or 4's, style 1 42
42. Fruit fleshy, flowers in heads or cymes ..... 43. *Cornaceae*
42. Fruit dry, flowers axillary or in racemes 43
43. Flowers yellow, plant densely clothed with short, barbed hairs, stamens many ..... 40. *Loasaceae*
43. Flowers white to pink or purple, stamens 2, 4 or 8, plant glabrous or appearing glabrous ..... 41. *Onagraceae*
44. Flowers somewhat papilionaceous ..... 32. *Polygalaceae*
44. Flowers, if irregular, not papilionaceous 45
45. Stamens more than 5 46
45. Stamens 5 or fewer 48
46. Petals united nearly their whole length ..... 44. *Ericaceae*
46. Petals only partially united 47
47. Stamens 6, 2 of the petals united along their upper half and at their bases ..... 23. *Fumariaceae*
47. Stamens more than 6, petals united at base with stamen tube ..... 37. *Malvaceae*
48. Ovary superior 49
48. Ovary inferior 60
49. Corolla more or less irregular 50
49. Corolla not at all irregular 53
50. Leaves alternate 51
50. Leaves opposite 52
51. Leaves reduced to scales, plants parasitic ..... 54. *Orobanchaceae*
51. Leaves not reduced to scales, plants not parasitic ..... 53. *Scrophulariaceae*
52. Mature ovary dividing into 2-4 nutlets ..... 51. *Labiatae*
52. Mature ovary a capsule, not becoming nutlets ..... 53. *Scrophulariaceae*
53. Pistils 2, ovaries distinct, becoming follicles ..... 47. *Apocynaceae*
53. Pistil 1, compound 54
54. Corolla dry-scarious, becoming papery ..... 55. *Plantaginaceae*
54. Corolla colored, not dry-scarious 55
55. Ovary 4-lobed, splitting into nutlets ..... 50. *Boraginaceae*
55. Ovary not 4-lobed, not becoming nutlets 56
56. Stamens opposite the corolla lobes ..... 45. *Primulaceae*
56. Stamens alternate with the corolla lobes 57
57. Ovary generally 3-loculed, rarely 2-, style usually 3-branched, rarely 2-branched ..... 48. *Polemoniaceae*
57. Ovary 1- or 2-loculed, style not 3-branched 58
58. Sepals separate nearly to the base ..... 49. *Hydrophyllaceae*
58. Calyx 5-lobed or shallowly parted 59
59. Leaves alternate, ovary 2-loculed ..... 52. *Solanaceae*
59. Leaves opposite, ovary 1-loculed ..... 46. *Gentianaceae*
60. Flowers in heads subtended by involucres, stamens 5, united into a tube by the anthers, calyx reduced to a pappus, or absent ..... 59. *Compositae*
60. Flowers, stamens and calyx not as above 61
61. Plants green, anthers opening by pores, or plants not green and anthers opening by slits ..... 44. *Ericaceae*
61. Plants green, anthers opening by slits 62
62. Leaves alternate ..... 58. *Campanulaceae*
62. Leaves opposite or in whorls 63
63. Leaves opposite, plants shrubby or vine-like ..... 57. *Caprifoliaceae*
63. Leaves opposite or in whorls, herbs, fruits splitting into 2 1-seeded nutlets which are berry- or bur-like ..... 56. *Rubiaceae*

Keys to Genera and Species

(Note: In discussions of species an asterisk (*) preceding the number indicates that the species was reported by Merriam (13) either under the listed name or a synonym of it.)

1. Equisetaceae, Horse-tail Rush Family

1. *Equisetum arvense* L. Horsetail Rush.— In the wet bottom of a creek near the McCloud River Railroad tracks at Howard.

2. Ophioglossaceae, Adder's Tongue Family

2. *Botrychium lunaria* (L.) Sw. var. *minganense* (Vict.) Dole. Moonwort. —Seen only near the lower end of the moist portion of the Sisson Southern Trail Spring.

3. Polypodiaceae, Fern Family

Key to Genera

1. Sori marginal 2
1. Sori not marginal 5
2. Leaf stalks stout, solitary ..... *Pteridium*
2. Leaf stalks slender, clustered 3
3. Fronds hairy or wooly ..... *Cheilanthes*
3. Fronds glabrous 4
4. Sterile and fertile fronds similar ..... *Pellea*
4. Sterile and fertile fronds very different from each other ..... *Cryptogramma*
5. Sori oblong, placed obliquely on the veins ..... *Athyrium*
5. Sori round 6
6. Indusium conspicuous, peltate ..... *Polystichum*
6. Indusium inconspicuous or lacking 7
7. Indusium lacking ..... *Athyrium*
7. Indusium inconspicuous but present 8
8. Indusium placed beneath the sorus ..... *Woodsia*
8. Indusium attached at the side ..... *Cystopteris*

*3. *Pteridium aquilinum* var. *pubescens* Underw. Bracken.—Common throughout the chaparral, at Wagon Camp, in the Transition Zone forest and in the chaparral outliers in the Canadian Zone.

*4. *Cheilanthes gracillima* D. C. Eaton. Lace Fern.—In occasional patches in rock outcroppings in the Transition and Hudsonian Zones.

5. *Pellea brachyptera* (Moore) Baker. Sierra Cliff Brake.—Several plants occur on a rock outcropping along the Sisson Southern Trail at 4500 ft., and at MacBride Springs.

*6. *Cryptogramma acrostichoides* R.Br. Rock Brake. American Parsley Fern.—Fairly common under and beside rocks in the flats and slopes above Horse Camp and Panther Creek Meadows, and in the canyon of Horse Camp Creek.

Athyrium Roth, Lady Ferns

1. Indusium present, sori oblong ..... *A. Filix-femina* var.
1. Indusium absent, sori round, minute ..... *A. americanum*

*7. *A. Filix-femina* var. *californicum* Butters. California Lady Fern.—Three colonies seen. One small colony occurs in the bog at Wagon Camp, one at

the outlet of the Municipal Spring, and one, where the fern is very common, along one of the larger springs on the west side of Mud Creek Canyon.

*8. *A. americanum* (Butters) Maxon. Mountain Lady Fern.—Very abundant in the canyon of Horse Camp Creek, common on the northeast side of Red Butte, and occasional in the flats above Panther Creek meadows.

Polystichum Roth, Sword Ferns

1. Fronds bipinnatifid ..... *P. scopulinum*
1. Fronds simply pinnate ..... *P. munitum* var.

*9. *P. scopulinum* (D.C.Eaton) Maxon. Shield Fern.—Plants have been found on a dry lava outcropping near Panther Creek Meadows, under a lava boulder near one of the springs at 9000 feet above Panther Creek, and under ledge-like boulders above Horse Camp Creek.

10. *P. munitum* var. *imbricans* (D.C.Eaton) Maxon. Imbricated Sword Fern.—Several plants form a colony on the outcropping of lava along the Sisson Southern Trail at 4500 feet.

11. *Woodsia scopulina* D.C.Eaton. Rocky Mountain Woodsia.—Several very small plants grow on a rock cliff above the Pines on the North Ridges. Another small colony occurs on the north side of Red Butte. An additional colony was found on the Red Ridge above and west of Panther Creek Meadow.

*12. *Cystopteris fragilis* (L.) Bernh. Brittle Fern.—A small colony grows at Wagon Camp, and another in the moist area of the Sisson Southern Trail Spring.

4. PINACEAE, Pine Family

KEY TO GENERA

1. Needles in fascicles of 2 to 5 ..... *Pinus*
1. Needles placed singly on the branches 2
  2. Bracts below the scales long exserted, three-pointed ..... *Pseudotsuga*
  2. Bracts below the cone scales short exserted or inevident 3
3. Cones erect on the branches, scales falling separately ..... *Abies*
3. Cones pendulous, scales not falling separately ..... *Tsuga*

Pinus L., The Pines

1. Needles in bundles of 5's 2
1. Needles in bundles of 2's or 3's 4
  2. Cones short-stalked or nearly sessile ..... *P. albicaulis*
  2. Cones long stalked, long and slender when closed 3
3. Cones 6-8 inches long, narrow ..... *P. monticola*
3. Cones 13 to 18 or more inches long, broader ..... *P. Lambertiana*
  4. Needles in 2's, cone scales ending in a prickle, cones 1-1½ inches long ..... *P. contorta* var.
  4. Needles in 3's, cones larger 5
5. Cones nearly sessile, opening soon after maturity, large trees of the forest ..... *P. ponderosa*
5. Cones sessile, one-sided, cone scales with swollen tips, small cones rarely opening before being burned or in age, tree on the edge of the forest and in the chaparral ..... *P. attenuata*

*13. *P. albicaulis* Engelm. White-Bark Pine.—The characteristic tree of

the Hudsonian Zone. It extends around the mountain at and above timberline and reaches down in occasional tall individuals to the Canadian Zone. It forms the Merriam timberline around the mountain where it is represented by low mats of less than a foot in height.

*14. *P. monticola* Don. Silver Pine, Idaho or Western White Pine.—Occurs largely on the northeast slopes. Isolated individuals rarely occur on the west side. Largely confined to the Canadian zone, at least except in Mud Creek Canyon where it is found from timberline to the chaparral.

*15. *P. Lambertiana* Dougl. Sugar Pine.—An important tree of the Transition Zone but largely logged off. Occasional individuals are seen from the roads and trails. Seedlings are common.

*16. *P. contorta* Dougl. var. *Murrayana* Engelm. Tamarac or Lodgepole Pine.—Characteristic of the Transition Zone on the northeast slopes where it extends up into the Canadian Zone. It occurs in pure stands along the old military road.

*17. *P. ponderosa* Dougl. Western Yellow Pine.—Characteristic of the Transition Zone where, on the south and southwest slopes, isolated trees in the chaparral and young groves on the lower slopes of the mountain are striking features of the forest. Altitudinally this intergrades with its variety:

17a. *P. ponderosa* var. *Jeffreyi* Vasey. Jeffrey Pine.—Occasional in the same range as the species but at higher elevations.

*18. *P. attenuata* Lemmon. Knobcone Pine.—Occasional individual trees and groves are to be seen from east of Widow Spring to Bear Springs on the south slopes in the chaparral and on the edge of the Transition forest.

*19. *Pseudotsuga taxifolia* (Lamb.) Britt. Douglas Fir.—Occasional individuals and seedlings may be found in the upper Transition forest, and in isolated groves in the chaparral.

Abies Link, The true Firs

1. Cones small, bracts inconspicuous, leave usually 2-ranked..... .....*A. concolor*
1. Cones large, bracts exserted 1/3 their length, leaves usually twisted upward, rarely 2-ranked.....*A. magnifica* var.

*20. *A. concolor* Lindl. & Gord. White Fir.—A considerable portion of the Transition Zone forest is made up of this species which may occur locally in pure stands. It extends up into the lower fringes of the Canadian Zone. Isolated dwarf individuals are found above timberline.

*21. *A. magnifica* var. *shastensis* Lemmon. Shasta Red Fir, Silver Tip Fir.—A solid belt of this species occurs at between 6500 and 8000 feet around the southwest slopes of the mountain. On the other slopes the elevation varies but the belt is continuous around the mountain in the Canadian Zone and forms timberline. Individuals and groves of dwarves may extend into the Hudsonian zone above timberline.

*22. *Tsuga Mertensiana* (Bong.) Sarg. Black or Mountain Hemlock.—A large grove, dominating the forest, displaces the Shasta Fir in the Upper Canadian Zone at Squaw Valley Creek meadows. A smaller grove shares the borders of Panther Creek meadows with the Shasta Fir. Isolated groves occur at moist places around the mountain below timberline such as the small grove north of Diller Canyon and the scattered trees in the Shasta Fir forest between Squaw Valley Creek and Mud Creek Canyon. Where it occurs in quantity it extends in dwarfed individuals above timberline.

5. Cupressaceae, Cypress Family

1. Cone becoming fleshy, berry-like; needles long awl-shaped ..... *Juniperus*
1. Cone becoming woody, needles scale-like ..... *Libocedrus*

*23. *Juniperus communis* L. var. *montana* Ait. Dwarf Juniper.—Extends around most of the mountain above timberline. Colonies may be found on the north side of Red Butte, in the flats and on the ridges above Panther Creek meadows, on the south and north banks of Diller Canyon, in large groves in the upper part of the lava flow on the north side of Shastina, and between Inconstance and Bolam Creeks on the north side of the mountain, as well as at other stations.

*24. *Libocedrus decurrens* Torr. Incense Cedar.—One of the commonest trees left in the Transition Zone occurring in the forest and chaparral. It is most noticeable near MacBride Springs, Bear Springs, and on the recent lava flow north of the Sisson Southern Trail.

6. Gramineae, The Grass Family

Key to the Tribes

1. Spikelets sessile ..... *A. Hordeae*
1. Spikelets pedicellate 2
2. Spikelets 1-flowered ..... *B. Agrostideae*
2. Spikelets 2 or more flowered 3
3. Glumes at least as long as the lowest floret ..... *C. Aveneae*
3. Glumes shorter than the lowest floret ..... *D. Festuceae*

Keys to Genera and Species

A. Hordeae

1. Rachis disarticulating at the joints ..... *Sitanion*
1. Rachis not disarticulating, at least until very old ..... *Elymus*

Sitanion Raf. Squirrel-tail Grasses

1. Glumes 3-5 nerved, plants of low elevations ..... *S. Hansenii*
1. Glumes 1-2 nerved, plants of high elevations ..... *S. Hystrix*

25. *S. Hansenii* (Scribn.) J.G.Smith. Hansen's Squirrel-tail.—Common in the Transition Zone.

*26. *S. Hystrix* (Nutt.) J.G.Smith. Squirrel-Tail Grass.—Common in the Canadian and Hudsonian Zones, becoming dwarfed at its upper limit—about 9500 feet.

Elymus L. Blue Wild Rye

1. Sheaths and blades glabrous ..... *E. glaucus*
1. Sheaths and blades pubescent ..... *E. glaucus* var.

27. *E. glaucus* Buckl. Smooth Blue Wild Rye.—One of the commonest grasses of the Transition Zone. Very common in the meadow below MacBride Springs.

27a. *E. glaucus* var. *Jepsonii* Davy. Hairy Blue Wild Rye.—Several plants occur near the lower end of the meadow at eBar Springs. Not seen elsewhere.

B. AGROSTIDEAE

1. Callus well developed, bearded ..... *Stipa*
1. Callus not well developed 2
2. Glumes usually shorter than the lemma ..... *Muhlenbergia*
2. Glumes equalling or longer than the lemma 3
3. Panicle densely compacted ..... *Phleum*
3. Panicle loose, not compact ..... *Agrostis*

Stipa L. Needle Grasses

1. Pubescence on lemma equal in length throughout ..... *S. occidentalis*
1. Pubescence on lemma shorter below, longer above ..... *S. californica*

28. *S. occidentalis* Thurb. Western Needle Grass. Generally confined to the Canadian and Hudsonian Zones but found along the Sisson Southern Trail as low as MacBride Springs.

29. *S. californica* Merr.&Davy. California Needle Grass.—Generally confined to the chaparral but also present throughout the Transition Zone and scattered through the Canadian Zone. If the chaparral should be discussed as a grass association it could be called an *Elymus glaucus-Stipa californica-Bromus carinatus* association.

Muhlenbergia Schreb. Muhly

1. Lemma faintly nerved, 4-5 mm. long, plant perennial ..... *M. Jonesii*
1. Lemma strongly nerved, 2 mm. long, plant annual ..... *M. filiformis*

30. *M. Jonesii* (Vasey) Hitchc. Jones' Muhly.—Common in an opening in the chaparral below Wagon Camp.

31. *M. filiformis* (Thurb.) Rydb. Pull-up Muhly.—Common along the road and near springs and streams between Wagon Camp and Bear Springs.

Phleum L. Timothy

1. Awns of the glumes 1.5-2 mm. long ..... *P. alpinum*
1. Awns of the glumes 1 mm. long ..... *P. pratense*

32. *P. alpinum* L. Alpine Timothy.—Common in the boreal springs above Panther Creek Meadows. Occasional plants also seen at Bear Springs and Horse Camp.

33. *P. pratense* L. Timothy.— Occasional plants found in the water system meadow at Horse Camp; also established in small colonies at Wagon Camp and Bear Springs.

Agrostis L. Red Top

1. Palea absent or greatly reduced 2
1. Palea at least half as long as the lemma 4
2. Panicle contracted, at least some of the lower branches spikelet bearing from near the base 3

2. Panicle open, sometimes diffusely spreading, lower branches not spikelet bearing from the base.....*A. hiemalis*
3. Plants 7-15 cm. tall, leaves mostly basal, less than 5 cm. long .....*A. Rossae*
3. Plants 25-50 cm. tall, stem leaves conspicuous, leaf blades 8-12 cm. long....*A. exarata*
4. Rachilla prolonged beyond the palea as a minute bristle.....*A. Thurberiana*
4. Rachilla not prolonged beyond the palea.....*A. alba*

34. *A. hiemalis* (Walt.) B.S.P. Tickle Grass.—Occasional in the vicinity of MacBride Springs.

35. *A. Rossae* Vasey. Ross' Red Top.—Common in the boreal springs on the southwest slopes of the mountain.

36. *A. exarata* Trin. Spike Red Top.—Common along the road between Wagon Camp and Bear Springs, at those two meadows, and in the Mud Creek Canyon.

37. *A. Thurberiana* Hitchc. Thurber's Red Top.—Common in the boreal springs on the southwest slopes of the mountain, especially at those above Horse Camp.

38. *A. alba* L. Red Top.—Established locally in the meadows formed from overflow of the water system at Horse Camp.

C. AVENEAE

1. Spikelets 2-flowered 2
1. Spikelets several flowered.....*Danthonia*
2. Lemmas keeled, the awn, when present, from above the keel.....*Trisetum*
2. Lemmas convex, awned from below the middle.....*Deschampsia*

39. *Danthonia intermedia* Vasey. Timber Oat Grass.—Found in the heather meadows along the upper portions of Squaw Valley Creek and in the small meadow on east Panther Creek between Red and Gray Buttes.

40. *Trisetum spicatum* (L.) Richt.—Common in the boreal springs around the southwest slopes of the mountain. It forms fair sized clumps when growing in the water or in marshy places near it. It also occurs in scattered clumps, in each of which only one or two scapes occur, throughout the dryer slopes and flats in the Hudsonian and upper Canadian Zones.

Deschampsia Beauv. Hair Grass

1. Plants annual, foliage very scant.....*D. danthonioides*
1. Plants perennial, foliage ½ to 1/3 entire length of culm .....*D. atropurpurea*

41. *D. danthonioides* (Trin.) Munro. Annual Hair Grass.—Several plants were collected in the dryer part of the lower Wagon Camp meadow.

42. *D. atropurpurea* (Wahl.) Scheele. Mountain Hair Grass.—Common along the creek at the lower portion of the Squaw Valley Creek meadows area.

D. FESTUCEAE

1. Upper florets sterile, reduced .....*Melica*
1. All florets alike 2

2. Nerves of lemma parallel.....*Glyceria*
2. Nerves of lemma converging toward the summit..... 3
3. Lemmas awn-tipped from a minutely bifid apex.....*Bromus*

3. Lemmas, if awned, awned from the tip 4
4. Spikelets awned ..... *Festuca*
4. Spikelets awnless ..... *Poa*

Melica L. Melic Grass

1. Lemmas obtuse ..... *M. californica*
1. Lemmas acute or awned 2
2. Lemmas long awned ..... *M. aristata*
2. Lemmas acute or short awned ..... *M. subulata*

43. *M. californica* Scribn. California Melic Grass.—Found in the forest, chaparral and meadow around Wagon Camp.

44. *M. aristata* Thurb. Awned Melic Grass.—Found along the Sisson Southern Trail above MacBride Springs and at the Spring area.

45. *M. subulata* (Griseb.) Scribn. Alaska Onion Grass.—Found in the Wagon Camp meadows.

46. *Glyceria elata* (Nash) Hitchc. Tall Manna Grass.—Occasional in the creeks at Bear Springs and Wagon Camp.

Bromus L. Brome Grasses

1. Lemmas compressed keeled ..... *B. carinatus*
1. Lemmas not compressed keeled 2
2. Lemmas broad, rounded above ..... *B. mollis*
2. Lemmas narrow, acuminate ..... *B. tectorum*

47. *B. carinatus* Hook.&Arn. California Brome.—Common throughout the chaparral and up into the Canadian Zone along the Sisson Southern Trail, the Memorial Highway, and the Wagon Camp-Horse Camp Trail.

48. *B. mollis* L. Soft Chess.—Common in one small moist location between Bear Springs and Wagon Camp.

49. *B. tectorum* L. Downy Chess.—Locally common in places throughout the chaparral especially at the lava outcropping along the Sisson Southern Trail at 4500 feet, and between Wagon Camp and Bear Springs.

Festuca L. Fescue Grasses

1. Blades of leaves flat, 3-5 mm. wide ..... *F. elatior*
1. Blades involute, 1 mm. wide, or if flat, less than 3 mm. wide 2
2. Awn as long or longer than the body of the lemma ..... *F. occidentalis*
2. Awn shorter than the body of the lemma ..... *F. idahoensis*

50. *F. elatior* L. Meadow Fescue.—A small colony has become established in the water system overflow at Horse Camp. Another larger colony occurs at Bear Springs.

51. *F. occidentalis* Hook. Western Fescue.—A small colony occurs at MacBride Springs.

52. *F. idahoensis* Elmer. Bluebunch Grass, Idaho Fescue.—One large clump was observed near the road between Bear Springs and Wagon Camp. It may be more abundant to the south of this point.

Poa L. Blue Grasses

1. Creeping rhizomes present ..... *P. pratensis*
1. Creeping rhizomes wanting 2
2. Blades of culms 2-3 mm. wide, flat, those of innovations slender or filiform ..... *P. epilis*
2. Blades of culms and innovations similar ..... *P. Pringlei*

53. *P. pratensis* L. Kentucky Blue Grass.—Well established in the meadows at Horse Camp, Wagon Camp, Bear Springs and MacBride Springs.

54. *P. epilis* Scribn. Skyline Bluegrass.—Infrequent. In one of the boreal springs above Panther Creek meadows, and near the upper limits of the Hudsonian Zone on the ridge north of Horse Camp.

55. *P. Pringlei* Scribn. Pringle's Bluegrass.—Occasional. Scattered among the blocks of lava along the Summit Trail from above the first mile post to the vicinity of Lake Helen.

7. Cyperaceae, Sedge Family

1. Achene surrounded by a perigynium or sac-like bractlet, perianth absent ..... *Carex*
1. Perigynium absent, perianth present in the form of barbed, hair-like awns ..... *Eleocharis*

Carex L. Sedges

Key to Sections

1. Spike 1, androgynous, bractless 2
1. Spikes 1-many, if 1, not as above 3
2. Perigynia inflated, sessile ..... 1. *Inflatae*
2. Perigynia not inflated, stipitate ..... 2. *Athrochlaenae*
3. Achenes lenticular, stigmas 2; lateral spikes sessile; terminal spike partially pistillate, or if staminate the lateral spikes short or heads dioecious 4
3. Achenes triangular and stigmas 3, or lenticular and stigmas 2; if lenticular lower lateral spikes conspicuously peduncled, or terminal spike staminate and lateral spikes elongated 7
4. Spikes gynecandrous 5
4. Spikes androgynous 6
5. Perigynia at most thin edged ..... 3. *Stellulatae*
5. Perigynia narrowly to broadly wing-margined ..... 4. *Ovales*
6. Perigynia abruptly contracted into a beak ..... 5. *Muhlenbergianae*
6. Perigynia tapering into a beak ..... 6. *Stenorhynchae*
7. Perigynia closely enveloping the achene, strongly tapering at the base, pubescent or puberulent, bracts sheathless or nearly so ..... 7. *Montanae*
7. If perigynia as above, bracts sheathing 8
8. Lowest bract strongly sheathing, perigynia never strongly bidentate with stiff teeth 9
8. Lowest bract sheathless or sheathing; if sheathing perigynia strongly bidentate with stiff teeth 11
9. Achenes lenticular, stigmas 2 ..... 8. *Bicolores*
9. Achenes triangular, stigmas 3 10
10. Scales dark reddish brown to blackish tinged ..... 9. *Frigidae*
10. Scales greenish or light reddish-brown or purplish tinged ..... 10. *Triquetrae*
11. Achenes triangular, stigmas 3 ..... 11. *Atratae*
11. Achenes lenticular, stigmas 2 ..... 12. *Acutae*

Key to Species

1. *Inflatae*

*56. *Carex Brewerii* Boott. Brewer's or Alpine Sedge.—Common in the

Hudsonian and Subalpine Zones on open rock and talus slopes. Also near boreal streams.

2. *Athrochlaenae*

57. *Carex nigricans* C.A.Mey. Black Alpine Sedge.—Occasional in open lava fields in the upper Canadian, Hudsonian and Subalpine Zones. Common along streams and springs in the Canadian and Hudsonian Zones.

3. *Stellulatae*

58. *Carex ormantha* (Fern.) Mkze. Western Stellate Sedge.—Occasional in the Wagon Camp sedge swamp.

4. *Ovales*

1. Sheaths strongly prolonged upward at mouth opposite blade in a very membranous appendage ..... *C. fracta*
1. Upper sheaths concave or truncate at mouth opposite blade 2
2. Beak of perigynium flat and serrulate to the usually strongly bidentate tip ..... *C. subfusca*
2. Beak of perigynium terete toward apex, the upper 1-3 mm. smooth or nearly so 3
3. Perigynia appressed, nearly or entirely covered by the scales, the beaks not conspicuous in the spikes ..... *C. phaeocephala*
3. Upper part of perigynia conspicuous in the spikes, not covered by scales 4
4. Perigynia with narrow winged membranous or submembranous walls ..... *C. microptera*
4. Perigynia with thick, firm walls 5
5. Lower spikes more or less strongly separate ..... *C. Preslii*
5. Lower spikes more or less appressed 6
6. Perigynia small, 2.25-3.5 mm. long ..... *C. teneraeformis*
6. Perigynia longer, 3.5 mm. or more long ..... *C. amplectens*

59. *C. fracta* Mkze. Fragile-sheathed Sedge.—The commonest and most conspicuous sedge of lower elevations. Collected at MacBride Springs, Bear Springs, Mud Creek Canyon, and in the Wagon Camp sedge swamp.

60. *C. subfusca* W. Boott. Dusky Sedge.—Occasional in a small meadow at Horse Camp.

61. *C. phaeocephala* Piper. Mountain Hare Sedge.—Scattered among the lava rocks of slopes along the Summit Trail in the vicinity of Lake Helen in the Subalpine Zone.

62. *C. microptera* Mkze. Small Winged Sedge.—Scattered through the sedge swamp at Wagon Camp.

63. *C. Preslii* Steud. Presl's Sedge.—Frequent in large clumps on flats near Horse Camp and in Horse Camp Creek on the border between the Canadian and Hudsonian Zones.

64. *C. teneraeformis* Mkze. Delicate Sedge.—Occasional near the Municipal Spring and the Sisson Southern Trail Spring.

65. *C. amplectens* Mkze. Sedge.—Occasional in the sedge swamp at Wagon Camp.

5. *Muhlenbergianae*

66. *C. Hoodii* Boott. Hood's Sedge.—Occasional at Bear Springs and Wagon Camp.

6. *Stenorhynchae*

1. Leaves not clustered at the base, sheaths mottled green and white dorsally....*C. nervina*
1. Leaves clustered at the base, not mottled.....*C. Jonesii*

67. *C. nervina* Bailey. White-Veined Sedge.—Common along creeks and in the sedge swamp at Wagon Camy.

68. *C. Jonesii* Bailey. Jones' Sedge.—Occasional in the Sedge Swamp at Wagon Camp.

7. *Montanae*

1. Basal spikes not developed.....*C. inops*
1. Basal spikes present.....*C. Brainerdii*

69. *C. inops* Bailey. Long-stoloned Sedge.—Occasional in the Sisson Southern Trail spring.

70. *C. Brainerdii* Mkze. Brainerd's Sedge.—Frequent in the woods near the bottom of Mud Creek Canyon.

8. *Bicolores*

71. *C. aurea* Nutt. Golden Sedge.—Occasional in the sedge swamp at Wagon Camp.

9. *Frigidae*

1. Perigynia triangular or slightly flattened, the beak bidentulate; scales obtusish, the midvein not prominent at the apex.....*C. ablata*
1. Perigynia strongly flattened, the beak bidentate; scales sharp pointed with midvein prominent to apex.....*C. fissuricola*

72. *C. ablata* Bailey. American Cold-loving Sedge.—Occasional in the Wagon Camp sedge swamp.

73. *C. fissuricola* Mkze. Sedge.—Occasional along the meadows of Squaw Valley Creek.

10. *Triquetrae*

74. *C. Whitneyi* Olney. Whitney's Sedge.—Occasional in open woods along the Sisson Southern Trail.

11. *Atratae*

75. *C. spectabilis* Dewey. Showy Sedge.—Common in all springs above timberline on the southwest slopes except those above Horse Camp. Also common in the upper meadows of Panther Creek and Squaw Valley Creek.

12. *Acutae*

1. Some or all of the flowering culms arising laterally and not enveloped at base by previous year's tuft of leaves .....*C. eurycarpa*
1. Flowering culms arising from the center of the previous year's tuft of leaves and surrounded at the base with dried up leaves of previous year..... 2
2. Strongly stoloniferous, the culms arising one to few together, low.....*C. gymnoclada*
2. Culms taller, less stiff, in larger clumps 3
3. Perigynia coriaceous, sessile or nearly so .....*C. nebraskensis*
3. Perigynia membranaceous, strongly stipitate.....*C. Kelloggii*

76. *C. eurycarpa* Holm. Well-fruited Sedge.—Occasional in the sedge swamp at Wagon Camp.

77. *C. gymnoclada* Holm. Sierra Alpine Sedge.—Occasional in the sedge swamp at Wagon Camp.

78. *C. nebraskensis* Dewey. Nebraska Sedge.—Common in wet places in an old road near the Municipal Spring.

79. *C. Kelloggii* W. Boott. Kellogg's Sedge.—Occasional in the Wagon Camp sedge swamp.

Eleocharis R.Br. Spike Rushes

1. Plants small, heads few flowered ..... *E. pauciflora* var.
1. Plants large, heads elongate, many flowered ..... *E. macrostachya*

80. *E. pauciflora* (Lightf.) Lk. var. *Suksdorfii* (Beauvard.) Svenson. Suksdorf's Few-flowered Spike Rush.—Common locally and scattered through the meadows along Squaw Valley Creek and Panther Creek. Also in the Sedge Swamp at Wagon Camp.

81. *E. macrostachya* Britton. Large Spike Rush.—A small colony occurs in the upper portion of the Bear Springs meadow.

8. JUNCACEAE, Rush Family

1. Capsule 3- or 1-celled, seeds several to many in each cell ..... *Juncus*
1. Capsule 1-celled, with 1 or 3 seeds ..... *Luzula*

Juncus L., Rushes

1. Inflorescence apparently lateral, involucral bract erect, appearing like a prolongation of the stem 2
1. Inflorescence terminal, involucral bract not appearing to be a continuation of the stem 4
2. Flowers many to numerous, in open panicles ..... *J. balticus* var.
2. Flowers few, 1-3, low alpine or subalpine plants 3
3. Inner sheaths bristle-tipped ..... *J. Drummondii*
3. Inner sheaths bract-bearing ..... *J. Parryi*
4. Leaves not transversely ribbed, usually flat ..... *J. orthophyllus*
4. Leaves transversely ribbed by internal septae 5
5. Leaves narrow, terete or subterete, not equitant 6
5. Leaves equitant, usually flattened 8
6. Heads small, numerous, in large, compound panicles ..... *J. dubius*
6. Heads larger, 1-several in a panicle 7
7. Heads solitary ..... *J. Mertensiana*
7. Heads several in a panicle, with whitish or scarious bractlets at the base ..... *J. nevadensis*
8. Heads small, numerous, stamens 6 ..... *J. oxymeris*
8. Heads larger, stamens 3 ..... *J. ensifolius*

82. *J. balticus* Willd. var. *montanus* Engelm. Mountain Wire Rush.—Common in the meadows at Horse Camp, in the upper meadows of Squaw Valley and Panther Creeks, in the lower Squaw Valley Creek meadow (in which this is the dominant species), in the Wagon Camp sedge swamp, and in the upper portion of the meadow at Bear Springs.

83. *J. Drummondii* E.Mey. Drummond's Rush.—Occasional near the Sisson Southern Trail spring, near Squaw Valley Creek, and on the borders of Mud Creek Canyon, all of which locations occur in the Canadian Zone

*84. *J. Parryi* Engelm. Parry's or Alpine Rush.—Common on the lava slopes and ridges of the subalpine areas on the southwest slopes at least up to 10,000 feet. Common down Cascade Gulch and in its vicinity at least to 6500 feet in the Canadian Zone.

85. *J. orthophyllus* Coville. Broad-leaved Rush.—Dominant in the lower of the three subalpine springs at Horse Camp. Also occurring at Wagon Camp.

86. *J. dubius* Engelm. Doubtful Rush.—An immature specimen, doubtfully referred to this species, was collected at Wagon Camp.

87. *J. Mertensianus* Bong. Mertens' Rush.—Dominant in the upper two of the three subalpine springs above Horse Camp. Common in the other boreal springs on the south west slopes, and in the meadows at Squaw Valley and Panther Creeks.

88. *J. nevadensis* Wats. Nevada Rush.—Occasional in the Wagon Camp meadow.

89. *J. oxymeris* Engelm. Iris-leaved Rush.—Common at Wagon Camp and occasional at Bear Springs.

90. *J. ensifolius* Wikstr. 3-stamened Rush.—Common at Bear Springs.

91. *J.* sp.—A small collection was made at Bear Springs of a rush which Dr. Hermann has named in manuscript from material collected in western Siskiyou County by J. T. Howell.

Luzula DC., Wood Rushes

1. Bracts and bractlets conspicuously ciliate or fimbriate ..... *L. subcongesta*
1. Bracts and bractlets not fimbriate ..... *L. multiflora*

92. *L. subcongesta* Jepson. Alpine Wood Rush.—Common in the lower of the boreal springs at Horse Camp, in the two boreal springs above Panther Creek meadows, and occasional at Wagon Camp.

93. *L. multiflora* (Ehrh.) Lejeune. Common Wood Rush.—Common in the dryer portions and in the meadows of Wagon Camp and Bear Springs, as well as occurring at moist places between these areas.

9. Liliaceae, Lily Family

1. Fruit a berry ..... *Smilacina*
1. Fruit a capsule 2
2. Styles 3, distinct, plants with rootstocks 3
2. Style 1, 3-lobed or 3-parted, or none, plants with bulbs or corms 5
3. Leaves equitant, *Iris*-like ..... *Tofieldia*
3. Leaves not equitant 4
4. Stems glabrous, leaves mostly basal ..... *Zygadenus*
4. Stems more or less pubescent, very leafy ..... *Veratrum*
5. Stem from a tunicated bulb or corm 6
5. Stem from a scaly bulb 9
6. Flowers without bracts, anthers basifixed ..... *Calochortus*
6. Flowers with bracts 7
7. Flowers in racemes or panicles ..... *Schoenolirion*
7. Flowers in umbels or heads 8
8. Perianth segments distinct or nearly so, anthers versatile ..... *Allium*

8. Perianth segments generally forming a tube below, anthers basifixed on broadly inflated filaments ..... *Calliprora*
9. Anthers basifixed, style 3-cleft ..... *Fritillaria*
9. Anthers versatile, style entire ..... *Lilium*

Smilacina Desf., False Solomon's Seal

1. Flowers in a simple raceme ..... *S. stellata*
1. Flowers in a compound panicle ..... *S. amplexicaulis*

*94. *S. stellata* (L.) Desf. Star Flower.—Colonies occur at the lower end of Wagon Camp meadow and along the spring in Mud Creek Canyon.

95. *S. amplexicaulis* Nutt. Fat Solomon.—Mostly along the Sisson Southern Trail where it occurs individually or in colonies below 5500 feet in the forest and chaparral. It also occurs below Bear Springs near the Municipal Spring above Howard.

*96. *Tofieldia occidentalis* Wats. Tofield's Swamp Lily.—Common in the sedge swamp at Wagon Camp.

97. *Zygadenus paniculatus* (Nutt.) Wats. Sand Corn.—Scattered through the chaparral along the MacBride Springs road from 4500 to 5000 feet.

*98. *Veratrum californicum* Durand. Corn Lily, False Hellebore, False Skunk Cabbage.—Dominant in the Wagon Camp meadows. Common along the lower portions of Squaw Valley and Panther Creeks. Common in springs along Mud Creek Canyon walls.

Calochortus Pursh, Mariposa Tulips, Sego Lilies

1. Petals with blue hairs below, white above ..... *C. caeruleus* var.
1. Petals naked ..... *C. nudus* var.

*99. *C. caeruleus* (Kell.) Wats. var. *maweanus* Jepson. Pussy Ears.—Along the road in moist places between Wagon Camp and Bear Springs. Commoner nearer Wagon Camp.

*100. *C. nudus* Wats. var. *shastensis* Jepson. Shasta Star Tulip.—Along the road in moist places between Wagon Camp and Bear Springs. Commoner toward Bear Springs.

*101. *Schoenolirion alba* Dur. Swamp Lily.—Common in the sedge swamp at Wagon Camp.

Allium L., Onions

1. Plants with rootstocks and bulbs ..... *A. vallidum*
1. Plants with only bulbs 2
2. Scapes 4-5 inches high ..... *A. campanulatum*
2. Scapes ¼ to 2½ inches high ..... *A. tribracteatum*

*102. *A. vallidum* Wats. Swamp Onion.—Common along the upper Wagon Camp creek, and in a smaller size along Panther and Squaw Valley Creeks in the heather meadows. Also in large size along springs in Mud Creek Canyon.

103. *A campanulatum* Wats. Chaparral Onion.—A small colony exists in a dry opening along the road below Wagon Camp.

*104. *A. tribracteatum* Torr. Dwarf Onion.—Probably the "*Allium* sp." of the Merriam report. Common in dry, sandy places along Panther and Squaw Valley Creek meadows outside the marshy portions, and in places through the Shasta Fir forest west of Panther Creek.

*105. *Calliprora scabra* var. *analina* Greene. Yellow Brodiaea.—Common in the dryer portions of the Wagon Camp meadow and below Wagon Camp.

*106. *Fritillaria atropurpurea* Nutt. Purple Bells.— Common in one colony just below Wagon Camp. Scattered at other places on the mountain from the chaparral along the Sisson Southern Trail, to a large sand flat between Panther Creek and Wagon Camp, to an isolated individual above timberline on the ridge south of Horse Camp in the Hudsonian Zone.

Lilium L., True Lilies

1. Bulb not rhizomatous, flowers white and purple dotted ..... *L. washingtonianum*
1. Bulb rhizomatous, flowers red and orange with purple spots..... *L. pardalinum*

*107. *L. washingtonianum* Kell. Shasta Lily, Washington Lily, Mountain Lily, Mt. Hood Lily, etc.—The most showy plant on Mount Shasta, when in bloom. It is common in the chaparral and the lower portions of the upper Transition Zone forest around the southwest slopes of the mountain. Because of its showiness it has now become rare since people unwisely dig the bulbs and injure the plant by pulling the flowers. It is now protected by law.

108. *L. pardalinum* Kell. Tiger or Leopard Lily.—Common at Wagon Camp, Bear Springs, and in springs along the walls of Mud Creek Canyon. It is also seen occasionally along temporary streams on the lower portion of the mountain. Plants with only one flower, or a large cluster of flowers, occur in the same colony.

10. IRIDACEAE, Iris Family

1. Calyx and corolla of different appearance, stems terete..... *Iris*
1. Calyx and corolla of similar parts, stems two-sided..... *Sisyrinchium*

109. *Iris tenuissima* Dykes. Chaparral Iris or Flag.—Common in the chaparral and seen along the roadside between Wagon Camp and Bear Springs.

*110. *Sisyrinchium bellum* Wats. Blue-eyes Grass.—Found in small to large colonies and clumps at Wagon Camp and Bear Springs and in moist places between.

11. ORCHIDACEAE, Orchid Family

1. Plants with chlorophyll, not saprophytes 2
1. Plants without chlorophyll, facultative saprophytes..... 3
2. One pair of round leaves occurring on the stem ..... *Listera*
2. Leaves not round, alternate, more than 2 ..... *Habenaria*
3. Plants pure white ..... *Cephalanthera*
3. Plants reddish to brownish ..... *Corallorhiza*

111. *Listera convallarioides* Torr. Twayblade.—Several patches occur along a spring on the west bank of Mud Creek Canyon.

Habenaria Willd., Rein Orchis

1. Flowers white ..... *H. leucostachys*
1. Flowers green 2

2. Stem leafy at base, plants of dry places.....*H. unalaschensis*
2. Stem leafy above as well as at the base, plants of swampy places.....*H. sparsiflora*

*112. *H. leucostachys* (Lindl.) Wats. Sierra Rein Orchis.—Common in the upper meadow at Wagon Camp, and throughout the wetter portions of Bear Springs. Small plants are found occasionally in the Squaw Valley Creek meadows.

*113. *H. unalaschensis* (Spreng.) Wats. Alaska Rein Orchis.—Occasionally found in dry places away from the borders of Wagon Camp and Bear Springs in groves of White Fir and Incense Cedar.

114. *H. sparsiflora* Wats. Green Bog Rein Orchis.—Common in the sedge swamp at Wagon Camp.

115. *Cephalanthera Austinae* (Gray) Hel. Phantom Orchis.—Three flowering heads were found under a White Fir in the chaparral below Bear Springs.

*116. *Corallorhiza maculata* Raf. Spotted Coral Root.—Scattered throughout the Canadian Zone forest.

12. SALICACEAE, Willow Family

1. Flowers without a disk, leaves lanceolate or cuneate-obovate, stamens 1-9.....*Salix*
1. Flowers with a broad disk, leaves broad, stamens 6-80.....*Populus*

Salix L., Willows

1. Stamens 3-9, filaments of stamens woolly or hairy below.....*S. lasiandra*
1. Stamens 2, filaments mainly glabrous 2
2. Style none, leaves obovate, glabrate or short-silky beneath.....*S. Scouleriana*
2. Style evident, leaves densely tomentose and silky beneath.....*S. sitchensis*

*117. *S. lasiandra* Benth. Yellow Willow.—A few small shrubs were found in the bottom of Mud Creek Canyon.

*118. *S. Scouleriana* Barr. Nuttall's Willow.—Common throughout the chaparral belt and Transition Zone. Extends up the canyon along the Sisson Southern Trail to the spring. Usually found along depressions in chaparral which might indicate an underground source of water supply. The largest thickets are at MacBride Springs, Bear Springs, the Municipal Spring and along the Sisson Southern Trail.

*119. *S. sitchensis* Sanson. Sitka or Velvet Willow.—Several small shrubs were found in the bottom of Mud Creek Canyon.

Populus L., Poplars or Cottonwoods

1. Stamens 40-80, leaves longer than broad.....*P. trichocarpa*
1. Stamens 6-12, leaves round ovate.....*P. tremuloides*

120. *P. trichocarpa* T.&G. Black Cottonwood.—Common along the floor of Mud Creek Canyon and out into the devastated area as either shrubs or trees up to 30 or more feet tall.

121. *P. tremuloides* Michx. Quaking Aspen.—A large scattered grove occurs in the White-Bark Pine forest near the top of the lava flow on the north

side of Shastina. These trees are mostly stunted and bush-like. Good sized trees occur along Pilgrim Creek east of Widow Spring. The first habitat is Hudsonian, the second Transition, in zonal position.

13. Betulaceae, Birch Family

*122. *Alnus viridis* DC. var. *sinuata* Regel. Thin-leaf Alder.—Common in large thickets along the bank of Mud Creek Canyon from above timberline to near the mouth of the Canyon. The dense mats of green seen on the canyon walls from the rims are caused by these dense thickets.

14. Fagaceae, Beech Family

1. Fruit an acorn, leaves pinnately lobed.....*Quercus*
1. Fruit a burr enclosing several nuts, leaves simple, entire or occasionally undulate ..... *Castanopsis*

*123. *Quercus Kelloggii* Newb. California Black Oak.—Scattered groves occur in the chaparral along the lower limits covered by this report on the southwest slopes of the mountain.

Castanopsis Spach, Chinquapin

1. Leaves mostly pointed, shrubs of the chaparral.....*C. chrysophylla*
1. Leaves mostly round at the tips, shorter, shrubs of the chaparral and timberline regions .....*C. sempervirens*

124. *C. chrysophylla* A.DC. Golden Chinquapin.—One of the more important shrubs of the chaparral extending throughout that sub-zone.

*125. *C. sempervirens* Dudley. Bush Chinquapin.—Occasional throughout the chaparral but more abundant with *Arctostaphylos nevadensis* along the upper limits of the White-Bark Pine zone.

15. Loranthaceae, Mistletoe Family

1. Berry sessile, flowers globose.....*Phoradendron*
1. Berry on a recurved pedicel, flowers compressed .....*Arceuthobium*

126. *Phoradendron Libocedri* (Engelm.) Howell. Cedar Mistletoe.—A common parasite on *Libocedrus decurrens*.

Arceuthobium Marsch-Bieb., Pine Mistletoe

1. Flowers blossoming in the spring, plants minute.....*A. Douglasii*
1. Flowers blossoming in the late summer .....*A. campylopodum*

127. *A. Douglasii* Engelm. Douglas Fir Mistletoe.—Common as a parasite on older trees of *Pseudotsuga taxifolia*. Infected trees can be easily spotted through the presence on them of abnormally dense branching systems on either the whole tree or merely parts of it. The mistletoe plants are less than ½ inch tall and are dwarfed by the needles on the twigs.

128. *A. campylopodum* Engelm. Pine Mistletoe.—Because of the wide variations of this species on its different hosts Gill (10) has recognized the following forms:

1. Plants large, yellow, found on *Pinus ponderosa*.....forma *typicum*
1. Plants medium sized, green, found on species of *Abies*.....forma *Abietinum*
1. Plants minute, yellowish, found on *Pinus albicaulis*.....forma *cyanocarpum*

128a. *A. campylopodum* f. *typicum* Gill.—Common on *Pinus ponderosa* at Widow Springs and along the Sisson Southern Trail. Entire trees, or only branches may be infected and produce the bright colored plants.

128b. *A. campylopodum* f. *Abietinum* (Engelm.) Gill.—Common on *Abies concolor* along the Sisson Southern Trail. Found on one tree of *Abies magnifica* var. *shastensis* in the same area. This form is apparently less destructive than the other species and forms of Mistletoe on the mountain. No trees were seen whose death could be traced directly to this parasite in contrast with other members of the family.

128c. *A campylopodum* f. *cyanocarpum* (A. Nels.) Gill.—Very common on *Pinus albicaulis* on the north slope of Shastina. Not observed elsewhere. The "Witches' Broom" caused by this parasite is apparently fatal to the host since a forest of considerable size has been killed by it.

16. ARISTOLOCHIACEAE, Birthwort Family

*129. *Asarum Hartwegii* Wats. White-Veined Wild Ginger.—Common in the chaparral and below 5500 feet along the Sisson Southern Trail. Mostly found on the shady side of large lava boulders or in cracks in lava outcroppings. Also found commonly in the lava flow north of Cascade Gulch.

17. POLYGONACEAE, Buckwheat Family

1. Leaves opposite or basal, without sheathing stipules, involucre present ..... *Eriogonum*
1. Leaves alternate or basal, all with sheathing stipules, involucre absent 2
2. Sepals 5, equal, stigmas capitate ..... *Polygonum*
2. Sepals unequal, stigmas tufted 3
3. Leaves not reniform, sepals 6 ..... *Rumex*
3. Leaves reniform, sepals 4 ..... *Oxyria*

Eriogonum Michx., False Buckwheat

1. Flowers astipitate ..... *E. latifolium* ssp.
1. Flowers attenuate to stipitate 2
2. Caudex stout, little, if any, branched ..... *E. pyrolaefolium*
2. Caudex more slender, much and intricately branched 3
3. Flowers capitate at first, appearing as small umbels in fruit ..... *E. marifolium*
3. Flowers umbellate 4
4. Involucre toothed ..... *E. cupulatum*
4. Involucre deeply lobed ..... *E. umbellatum* ssp.

*130. *E. latifolium* Smith ssp. *nudum* (Dougl.) Stokes. Tibinagua.—Common through the chaparral below 4500 feet. Reaches up the mountain along the Sisson Southern Trail and in Mud Creek Canyon to the Canadian Zone. Both white and yellow flowers occur.

*131. *E. pyrolaefolium* Hook. Alpine Buckwheat.—Common around Mount Shasta in the Hudsonian Zone and extending up at least to 10,000 feet. It is abundant, in fact dominant, in some of the flat morainal basins from 8000 feet to 9500 feet and common on slopes between.

*132. *E. marifolium* T.&G. Mountain Buckwheat.—Common on the lava flats of the upper Canadian Zone and throughout the Hudsonian Zone. It rarely occurs above the limits of the White Bark Pine belt. It may descend to the edge of the Transition Zone.

133. *E. cupulatum* Stokes. McCloud Buckwheat.—Occasional through the upper Transition Zone especially near Wagon Camp.

134. *E. umbellatum* Torr. ssp. *polyanthum* (Benth.) Stokes. Sulphur Flower.—A small colony was found at about 7000 feet in a patch of *Arctostaphylos patula* west of Bolam Creek. A large colony occurs at about 6000 feet in Mud Creek Canyon.

Polygonum L., Knotweeds, Smartweeds, Wiregrasses

1. Leaves broad, not jointed to the petiole ..... *P. Davisae*
1. Leaves mostly narrow and lanceolate, jointed upon a short petiole adnate to the sheath, flowers in axiliary clusters 2
2. Perennial and more or less shrubby ..... *P. shastense*
2. Annuals, not shrubby 3
3. Flowers in very loose spikes, leaves reduced upwards 4
3. Flowers in axilary clusters, leaves little reduced upwards 5
4. Leaves linear oblong or linear lanceolate ..... *P. Douglasii*
4. Leaves oblong ..... *P. Douglasii* var.
5. Plants large, green, leaves linear oblong to lanceolate, achenes dull ..... *P. ramosissimum*
5. Plants minute 6
6. Plants red or reddish, leaves ovate to elliptic, flowers in axilary clusters ..... *P. minimum*
6. Plants green, flowers solitary in the axils of the leaves ..... *P. Parryi*

*135. *P. Davisae* Brew. Davis' Red Knotweed.—Common in open sandy lava flats and basins on the southwest slopes south of Horse Camp Creek at least to Mud Creek Canyon. Not seen north of Horse Camp Creek.

*136. *P. shastense* Brew. Shasta shrubby Knotweed.—Common around Mount Shasta in the Hudsonian and upper Canadian Zones.

137. *P. Douglasii* Greene. Douglas' Wire Grass.—Occasional in the meadows at Wagon Camp and Bear Springs as well as in Mud Creek Canyon.

137a. *P. Douglasii* var. *latifolium* Greene.—Common at MacBride Springs and found at Wagon Camp.

138. *P. ramosissimum* Michx. Erect Wire Grass.—Found once at Bear Springs.

139. *P. minimum* Wats. Small Red Knotweed.—Common near the springs in the South Gate and in the flats at that point. Also found commonly in Squaw Valley Creek meadows. In the latter location the plants become branched and have long internodes. In the former location the plants are compact and not branched.

140. *P. Parryi* Greene. Dwarf Green Knotweed.—In one sandy opening in the *Juncus* meadow on upper Squaw Valley Creek associated with *Polygonum minimum*, *Mimulus pulsiferae* and *Lewisia triphylla*. Together these dwarves, which measured 2 cm. high at the most, formed quite an extensive lawn.

Rumex L., Dock, Sorrel

1. Plant dioecious ..... *R. acetosella*
1. Plant monoecious ..... *R. crispus*

141. *R. acetosella* L. Sheep Sorrel.—Established on the mountain wherever it is moist enough and man with horses has spent a night. It occurs at Horse

Camp, Wagon Camp, Bear Springs and MacBride Springs.

142. *R. crispus* L. Curly Dock.—Several plants have become established at Bear Springs.

*143. *Oxyria dignya* (L.) Hill. Mountain Sorrel.—Occurs along the Summit Trail between 9000 and 10,000 feet. It also occurs on the north side of Red Butte and in loose rock on the northeast side of Red Butte just above the lowest Squaw Valley Creek meadow. The latter location is Canadian in zonal position, the others are upper Hudsonian and Subalpine.

18. Amaranthaceae, Amaranth Family

144. *Amaranthus retroflexus* L. Rough Pigweed.—A small colony has become established at Horse Camp.

19. Chenopodiaceae, Saltbush Family

145. *Chenopodium album* L. White Pigweed, White Goosefoot, Lambs's Quarters.—Several individuals have become established in the chaparral in the vicinity of Howard.

20. Portulacaceae, Purslane Family

1. Capsule circumscissile ..... *Lewisia*
1. Capsule 2-3 valved 2
   2. Style 1, stigmas 2, sepals plane ..... *Calyptridium*
   2. Style branches 3, sepals more or less concave ..... *Montia*

Lewisia Pursh, Western Spring Beauty

1. Stems with 2-3 leaves below the flowers ..... *L. triphylla*
1. Stems leafless, scape-like ..... *L. pygmaea*

*146. *L. triphylla* (Wats.) Rob.—Occurs in large colonies throughout the upper portions of Squaw Valley and Panther Creek meadows as well as near the springs in the South Gate. Together with *Polygonum minimum* this forms large red mats on the ground.

147. *L. pygmaea* (Gray) Rob.—Occurs in fewer numbers but with *L. triphylla*.

*148. *Calyptridium umbellatum* (Torr.) Greene. Pussy Paws.—Occasional through the upper Transition and Canadian Zones. Range overlaps that of the variety from which some specimens cannot easily be distinguished at higher elevations.

148a. *C. umbellatum* var. *caudicifera* (Gray) Jepson.—Occurs throughout the upper Canadian and Hudsonian Zones. It extends up the mountain as high as 9500 feet in the Subalpine Zone. It is usually found singly but may occur in large colonies.

Montia L., Indian Lettuce

1. Cauline pair of leaves more or less united 2
1. Cauline pair of leaves distinct ..... *M. siberica*
   2. Plant large, green, more or less succulent, in moist places ..... *M. perfoliata*
   2. Plant small, reddish, succulent, in dry places ..... *M. perfoliata* var.

149. *M. siberica* (L.) Howell. Northwest Indian Lettuce.—Several plants occur along the streams in Bear Creek meadows.

150. *M. perfoliata* (Donn.) Howell. Miner's Lettuce.—A large colony occurs under an Incense Cedar tree at Bear Springs. Other smaller colonies are scattered through the Bear Springs area.

150a. *M. perfoliata* var. *depressa* (Gray) Jepson.—Found only in one small colony near MacBride Springs.

21. Caryophyllaceae, Pink Family

1. Sepals united into a tubular calyx ..... *Silene*
1. Sepals separate or united only at base 2
2. Petals entire or notched, if present, styles as many as sepals and alternate with them ..... *Sagina*
2. Petals bifid or 2-divided, styles 3, 4 or 5, when of the same number opposite the sepals 3
3. Capsule cylindric, styles 5 ..... *Cerastium*
3. Capsule ovoid or oblong, styles 3 to 4 ..... *Stellaria*

Silene L., Catch-Fly, Campion

1. Plants of the chaparral ..... *S. Lemmonii*
1. Plants high montane, mostly near or above timberline 2
2. Leaves 2-3 lines broad ..... *S. Grayi*
2. Leaves 1 line broad ..... *S. Watsonii*

151. *S. Lemmonii* Wats. Chaparral Catch-Fly.—This occurs in scattered spots in the chaparral above Bear Springs along the road to Wagon Camp.

152. *S. Grayi* Wats. Gray's Catch-Fly.—Found commonly in the lower subalpine areas and in the Hudsonian Zone lava slopes and flats.

*153. *S. Watsonii* Rob. Watson's Catch-Fly.—Found on the subalpine slopes above Horse Camp along the Summit Trail just below 10,000 feet, on the north side of Red Butte, and on the west bank of Mud Creek Canyon.

Sagina L., Pearlwort

1. Stems filiform, pedicels straight ..... *S. occidentalis*
1. Stems stout, succulent, pedicels recurved at the tip ..... *S. Linnaei*

154. *S. occidentalis* Wats. Western Pearlwort.—Fairly common in the creeks among mosses and sedges along Wagon Camp and Bear Springs creeks and in moist places between them. Also in Mud Creek Canyon.

*155. *S. Linnaei* Presl. Arctic Pearlwort.—Occasional in the creeks in mosses at Squaw Valley and Panther Creek meadows. Also in a small spring at Horse Camp Creek.

156. *Cerastium viscosum* L. Mouse-ear Chickweed.—Occasional at Bear Springs and at moist places above them.

Stellaria L., Chick-Weed, Stichwort

1. Annuals ..... *S. media*
1. Perennials 2
2. Petals deeply 2-parted 3
2. Petals merely bifid ..... *S. Jamesiana*
3. Bracts small and scarious ..... *S. longipes*
3. Bracts foliaceous ..... *S. borealis*

157. *S. media* (L.) Cyr. Common Chickweed.—Infrequent along the upper Wagon Camp creek.

158. *S. Jamesiana* Torr. James' Chickweed.—In several colonies along the upper Wagon Camp creek.

159. *S. longipes* Goldie. Long-stemmed Checkweed.—In several colonies at Bear Springs.

160. *S. borealis* Bigl. Alpine Chickweed.—Common in the west boreal spring above Panther Creek Meadows, and occasional in the upper boreal spring above Horse Camp where it is associated with *Juncus Mertensiana*.

22. RANUNCULACEAE, Buttercup Family

1. Ovary usually with 1 ovule, fruit an achene 2
1. Ovary with several to many ovules, fruit a follicle or berry..... 3
2. Petals none, flowers large, achene with a long hairy tail..... *Anemone*
2. Petals present, flowers small, achene without such tail..... *Ranunculus*
3. Fruit a berry, one simple pistil in each flower of the raceme..... *Actaea*
3. Fruit a follicle, several simple pistils per flower 4
4. Flowers regular in shape 5
4. Flowers irregular in shape..... 6
5. Petals not spurred, inserted in a fleshy disk ..... *Paeonia*
5. Petals prolonged into sac-like spurs, disk absent ..... *Aquilegia*
6. Upper sepal spurred ..... *Delphinium*
6. Upper sepal helmet-like ..... *Aconitum*

*161. *Anemone occidentalis* Wats. Wind Flower, Pulsatilla.—South of Horse Camp Creek around the southwest slopes of the mountain in the Hudsonian Zone.

162. *Ranunculus occidentalis* Nutt. Western Buttercup.—A few plants grow in the meadows at Bear Springs.

163. *Actaea spicata* L. var. *arguta* Torr. White Baneberry.—Common in the Sisson Southern Trail Spring and under a grove of *Cornus californica* at Bear Springs.

*164. *Paeonia Brownii* Dougl. Western Peony.—Frequent around the outer, dryer edges of Wagon Camp meadow and in the chaparral along the MacBride Springs road below 4500 feet.

*165. *Aquilegia formosa* Fisch. Columbine.—Common in meadows at Bear Springs and Wagon Camp and in moist places between them.

*166. *Delphinium pauciflorum* Nutt. Blue Larkspur.—A good sized colony occurs at the lower edge of Wagon Camp.

*167. *Aconitum columbianum* Nutt. Western Monkshood.—Common along the springs at Bear Springs and Wagon Camp, and in a spring along the west bank of Mud Creek Canyon.

23. FUMARIACEAE, Fumitory Family

*168. *Dicentra uniflora* Kell. Steer's Head.—Frequent locally in the Canadian and Hudsonian Zones. Rarely seen because it comes up just after the snow melts, and fruits and dies within two weeks. At least between Horse Camp and Panther Creek meadows.

24. CRUCIFERAE, Mustard Family

1. Pod a silique, several times longer than wide 2
1. Pod a silicle, little more than 1-3 times as long as wide 8
2. Stems from tuberous rootstocks ..... *Cardamine*
2. Stems from annual or perennial roots or root crowns 3
3. Flowers yellow 4
3. Flowers white to purple or purplish 7
4. Leaves entire or dentate, not lobed, flowers large ..... *Erysimum*
4. Leaves lobed, flowers small 5
5. Pods terete, annual 6
5. Pods quadrangular, perennials ..... *Barbarea*
6. Pods short, plants small ..... *Descurainia*
6. Pods long, plants large ..... *Sisymbrium*
7. Petals with a broad limb, not twisted or crisped ..... *Arabis*
7. Petals usually with a narrow limb, crisped ..... *Streptanthus*
8. Pods more or less turgid ..... *Camelina*
8. Pods not turgid 9
9. Pods flattened parallel to the broad partition ..... *Draba*
9. Pods flattened contrary to the broad partition ..... *Lepidium*

Cardamine L., Bitter Cress

1. Leaves simple, undivided ..... *C. bellidifolia* var.
1. Leaves, at least the cauline, with 3-many pinnate leaflets ..... *C. Brewerii*

*169. *C. bellidifolia* L. var. *pachyphylla* Cov. & Leib.—Common under rocks in the subalpine areas above Horse Camp, Panther Creek Meadows and Squaw Valley Creek. Also in the South Gate, on the north side of Red Butte, and east to the edge of Mud Canyon, at least.

170. *C. Breweri* Wats.—A few plants grow along the creeks at Bear Springs.

*171. *Erysimum asperum* (Nutt.) DC. var. *perenne* Cov.—Western Wall Flower.—Common during wet seasons at MacBride Springs. A smaller form was found in open *Pinus ponderosa* woods near an old burn on the north side of the mountain near the North Gate.

172. *Descurainia sophia* (L.) Webb. Tansy Mustard.—A few plants were found at Bear Springs.

173. *Sisymbrium altissimum* L. Tumbling Mustard, Jim Hill Weed.—Common in the chaparral on the lower end of the Sisson Southern Trail, and at the lower Bear Spring.

174. *Barbarea orthoceras* Ledeb. Yellow Rocket.—A few plants are established at Bear Springs.

Arabis L., Rock Cress

1. Seeds nearly marginless ..... *A. glabra*
1. Seeds wing margined, pods flattish 2
2. Pods narrowly linear ..... *A. sparsiflora*
2. Pods broadly linear to oblong or elliptic 3
3. Pods pendant or deflexed ..... *A. suffrutescens*
3. Pods erect ..... *A. platysperma* var.

175. *A. glabra* (L.) Bernh. Tower Mustard.—Common at Bear Springs and in moist places in the chaparral below them.

176. *A. sparsiflora Nutt.*—Common in the lower portions of MacBride Springs.

177. *A. suffrutescens* Wats.—Material collected once at Wagon Camp in immature condition is tentatively referred to this species.

*178. *A. platysperma* Gray var. *Howellii* (Wats.) Jepson.—Common from the lower Canadian Zone to 9500 feet in the Subalpine Zone. It grows in open forest or under rocks on lava slopes and ridges.

*179. *Streptanthus orbiculatus* Greene. Purple Mustard.—Common in the lava slopes and flats above timberline. Also common around the subalpine springs above Horse Camp, and in the Horse Camp meadows.

180. *Camelina sativa* Crantz. False Flax.—Occasional individuals are seen in the lower chaparral along the Sisson Southern Trail.

*181. *Draba Breweri* Wats. Rock Cress.—Reported by Merriam at 13,000 feet between Konwakiton and Wyntoon Glaciers. Found on a Red Ridge west of and above Panther Creek meadows at about 9000 feet, below the upper limits of *Pinus albicaulis*.

182. *Lepidium campestre* R.Br. Field Peppergrass.—One individual was found in fruit at Horse Camp. It has not been seen there since the first collection in 1936.

25. Droseraceae, Sundew Family

*183. *Drosera rotundifolia* L. Sundew.—Common in the mosses at the Wagon Camp sedge swamp.

26. Crassulaceae, Stone Crop Family

184. *Sedum obtusatum* Gray. Stone Crop.—A small colony was found in the lower portion of Mud Creek Canyon.

27. Saxifragaceae, Saxifrage Family

1. Fruit a berry, ovary wholly inferior ..... *Ribes*
1. Fruit a capsule, ovary superior or partially inferior 2
2. Sterile filaments present, fertile filaments 5, ovary 1-celled, with as many stigmas as the 3-4 parietal placentae ..... *Parnassia*
2. Sterile filaments absent, fertile stamens 5-10, placentae 2 3
3. Fertile stamens 5, in ours opposite the petals, ovary 1-celled ..... *Mitella*
3. Stamens 10, ovary 2-celled ..... *Saxifraga*

Ribes L., Gooseberries, Currants

1. Stems long spinose 2
1. Stems and berries not spinose 3
2. Berries red, spinose ..... *R. Roezlii*
2. Berries blue-black, glabrous ..... *R. divaricatum*
3. Flowers pink or red, small ..... *R. nevadense*
3. Flowers white or greenish white 4
4. Calyx tube cylindric, berry crimson ..... *R. cereum*
4. Calyx tube campanulate, berry black ..... *R. viscosissimum*

*185. *R. Roezlii* Regel. Gooseberry.—Occasional along the Sisson Southern Trail above the chaparral and at Bear Springs. Rare in the chaparral. Also in Mud Creek Canyon.

186. *R. divaricatum* Dougl. Straggly Gooseberry.—Several bushes grow just above the outlet of the Municipal Spring at Howard.

187. *R. nevadense* Kell. Nevada Red Flowering Currant.—Several individuals grow at about 5500 feet along the Sisson Southern Trail.

*188. *R. cereum* Dougl. Sticky Red Currant.—Common in the chaparral, along the Sisson Southern Trail, in Mud Creek Canyon, and on the north slope of the mountain near timberline.

*189. *R. viscosissimum* Pursh. Black Currant.—Common at MacBride Springs, along the Sisson Southern Trail, on the north side of the mountain, and in Mud Creek Canyon in the Transition Zone.

*190. *Parnassia palustris* L. var. *californica* Gray. Grass of Parnassus.—Common throughout the Squaw Valley Creek meadow area.

*191. *Mitella pentandra* Graham. Bishop's Cap.—Common along the lower Squaw Valley and Panther Creek Cascades as well as in the springs along Mud Creek Canyon.

*192. *Saxifraga Tolmiei* T. & G. Tolmie's Alpine Saxifrage.—Common at about 10,000 feet near the Summit Trail and on both sides of the ridge south of that trail. Common on the north side of Red Butte, occasional on the west side of Shastina, on the south bank of Diller Canyon, and on the west bank of Mud Creek Canyon. Usually Subalpine.

28. ROSACEAE, Rose Family

1. Ovary superior 2
1. Ovary inferior 13
2. Fruit dehiscent, shrubs 3
2. Fruit indehiscent, shrubs or herbs 6
3. Stamens united at the base ..... *Luthea*
3. Stamens separate 4
4. Leaves compound, the leaflets minute ..... *Chamaebatiaria*
4. Leaves simple 5
5. Stamens well exserted, flowers rose color ..... *Spiraea*
5. Stamens scarcely exserted, flowers cream-color ..... *Holodiscus*
6. Ovary becoming a fleshy drupelet in an aggregate fruit on a convex receptacle ..... *Rubus*
6. Ovary becoming a drupe, trees or shrubs with simple leaves ..... *Prunus*
6. Ovary becoming an achene 7
7. Pistil 1, shrubs 8
7. Pistils more than 1, herbs or shrubs 9
8. Achene with a long, feathery tail, petals absent ..... *Cercocarpus*
8. Achene without a tail, petals present ..... *Purshia*
9. Herbs, pistils borne on a flat or convex receptacle 10
9. Shrubs, stems prickly, pistils on the inside of an urn-shaped receptacle ..... *Rosa*
10. Styles persistent on the achene ..... *Geum*
10. Styles deciduous from the achene 11
11. Receptacle becoming fleshy ..... *Fragaria*
11. Receptacle remaining dry 12
12. Petals white filaments dilated, stamens 10 ..... *Horkelia*
12. Petals yellow, filaments not dilated, stamens usually 20 or more ..... *Potentilla*
13. Leaves pinnately compound, flowers in compound corymbs ..... *Sorbus*
13. Leaves simple, flowers in short racemes ..... *Amelanchier*

*193. *Lutkea pectinata* (Pursh) Ktze.—Common around the alpine springs above Panther Creek meadows, common at the springs in the South Gate, common around the west branch of Squaw Valley Creek and at the head of the main creek, and in moist places between Squaw Valley and Mud Creeks. Between Red Butte and the main branch of Squaw Valley Creek this species replaces the commoner *Phyllodoce empetriformis* as a mat former over probably deep sources of underground water.

194. *Chamaebatiaria millefolium* (Torr.) Maxim. Desert Sweet.—Occasional in a small canyon west of Bolam Creek on the north side of the mountain.

*195. *Spiraea Douglasii* Hook. Spiraea.—Along a small intermittent spring creek just above Bear Springs along the Wagon Camp road. Several large colonies also occur on the east side of Mud Creek Canyon near the canyon floor.

*196. *Holodiscus discolor* (Pursh) Maxim var. *glabrescens* Heller. Mountain Cream Bush, Mountain Spray.—A low shrub which is usually associated with *Castanopsis sempervirens* and *Arctostaphylos nevadensis* near the upper limits of shrub growth in the Hudsonian Zone and down into the Canadian Zone. It is found in larger sizes in Mud Creek Canyon.

Rubus L., Raspberries, Blackberries, Brambles

1. Fruit oblong, drupelets persistent on the receptacle ..... *R. vitifolius*
1. Fruit conical or hemisphaerical, drupelets parting from the receptacle as a whole when ripe 2
2. Stems unarmed, leaves simple, palmately lobed ..... *R. parviflorus*
2. Stems prickly, leaves 3-foliate ..... *R. leucodermis*

197. *R. vitifolius* C. & S. California Blackberry.—Several vines, mostly prostrate on the ground, grow along the Sisson Southern Trail in the chaparral.

198. *R. parviflorus* Nutt. Thimbleberry.—Common in the chaparral, especially near the Municipal Spring, MacBride Springs and along the Sisson Southern Trail.

199. *R. leucodermis* Dougl. Western Raspberry.—Mostly along the Sisson Southern Trail. Occasional bushes grow at 4500, 5200 and 6500 feet.

Prunus L., Peaches, Plums, Cherries

1. Drupe oblong, leaves rolled up from one edge to the other in the bud ..... *P. subcordata*
1. Drupe subglobose or ovoid, leaves folded together lengthwise in the bud 2
2. Flowers in corymbs ..... *P. emarginata*
2. Flowers in racemes ..... *P. demisa*

200. *P. subcordata* Benth. Sierra Plum.—A small grove in the chaparral extends along the MacBride Springs road below the springs.

*201. *P. emarginata* (Dougl.) Walp. Bitter Cherry.—In the chaparral belt is a secondary zone formed almost exclusively of this species at about 4300 feet both along the Sisson Southern Trail, the MacBride Springs road, and the Wagon Camp road. The berries look tempting to eat but are exceedingly bitter. Occasional shrubs are scattered about the chaparral and extend up to the Canadian Zone.

*202. *P. demisa* (Nutt.) Dietr. Western Choke Cherry.—A considerable grove occurs at the source of MacBride Springs and another grove is found along the MacBride Springs road below the grove of *P. subcordata*, and near groves of *P. emarginata* and *Amelanchier alnifolia*.

*203. *Cercocarpus ledifolius* Nutt. Mountain or Desert Mahogany.—A few trees of good size occur in the *Pinus albicaulis* forest on the north side of Shastina on a ridge at the south edge of the lava flow. It extends sparsely through the upper portion of the lava flow. It is also found in the small canyon west of Bolam Creek in the Transition Zone.

*204. *Purshia tridentata* DC. Antelope Brush.—Occasional in the chaparral around the mountain. It extends up the Sisson Southern Trail to 6000 feet. It is Dominant in the understory of the Transition Zone forest on the lava flow north of Cascade Gulch between 5500 feet and MacBride Springs

*205. *Rosa gymnocarpa* Nutt. Wood or Chaparral Rose.—Occasionally scattered throughout the chaparral from Bear Springs to MacBride Springs and Howard.

206. *Geum macrophyllum* Willd. Big Leaf Avens.—Frequent at Bear Springs in the meadow.

Fragaria L., Strawberries

1. Achenes in deep pits in the receptacle, inflorescence sub-umbellate....*F. virginiana* var.
1. Achenes superficial or in shallow pits, inflorescence irregularly branched and becoming elongate ..... *F. californica*

207. *F. virginiana* Duch. var. *platypetala* Hall. Scarlet Strawberry.—Common at MacBride Springs and occasional in the chaparral below Bear Springs. Also at Wagon Camp.

208. *F. californica* C. & S. Wood Strawberry.—Common at Wagon Camp and scattered in the chaparral down to Howard.

*209. *Horkelia fusca* Lindl. ssp. *pseudocapitata* (Rydb.) Keck.—Common along the road along intermittent creeks and in rather dry places between Bear Springs and Wagon Camp.

Potentilla L., Five-Finger

1. Style lateral, ovules ascending ..... *P. Sibbaldii*
1. Style terminal or nearly so, ovules pendulous 2
2. Leaves pinnate ..... *P. glandulosa*
2. Leaves palmately compound 3
3. Leaflets oblanceolate, 5-7 per leaf ..... *P. gracilis* ssp.
3. Leaflets broadly obovoid, 3 per leaf ..... *P. flabellifolia*

*210. *P. Sibbaldii* Hal. f.—Common in the subalpine springs around the southwest slopes of the mountain. Also in the upper portions of Squaw Valley Creek.

*211. *P. glandulosa* Lindl.—Two subspecies are reported:

211a. *P. glandulosa* ssp. *nevadensis* (Wats.) Keck.— Common at MacBride Springs. Occasional at Bear Springs and up to Wagon Camp.

211b. *P. glandulosa* ssp. *pseudoruprestris* (Rydb.) Keck.—Isolated clumps of individuals are found in the Hudsonian Zone on the ridges south of Horse

Camp, on the north side of Shastina, in Horse Camp Creek, and on the west bank of Mud Creek Canyon.

212. *P. gracilis* Dougl. ssp. *Nuttallii* (Lehm.) Keck.—Occasional plants are found at Bear Springs.

*213. *P. flabellifolia* Hook.—This is our most beautiful *Potentilla* and is found only in the springs in the South Gate.

*214. *Sorbus sitchensis* Roem. Western Mountain Ash.—Several shrubs occur near the Sisson Southern Trail Spring. A colony of shrubs is located near the Municipal Spring. Occasional shrubs are seen in the Alder thickets in Mud Creek Canyon.

*215. *Amelanchier alnifolia* Nutt. Western Service Berry.—Common at the lower end of Bear Springs. One specimen stands along the Sisson Southern Trail at about 5500 feet. A grove extends along the MacBride Springs road below the groves of *Prunus emarginata, P. demisa* and *P. subcordata* in the chaparral. Scattered plants are found in the chaparral. It also occurs in alder thickets in Mud Creek Canyon.

29. LEGUMINOSAE, Legume or Pea Family

1. Calyx deeply 2-lipped ..... *Lupinus*
1. Calyx not deeply 2-lipped 2
    2. Leaves palmately 3-foliate ..... *Trifolium*
    2. Leaves pinnately compound, 3-many foliate 3
3. Leaves odd-pinnate, tendrils absent ..... *Lotus*
3. Leaves equally pinnate, terminated by a tendril 4
    4. Style terete, hairy all around at summit ..... *Vicia*
    4. Style flattened, hairy only on upper side ..... *Lathyrus*

Lupinus L., Lupines

1. Pedicels short and stout ..... *L. Lyallii*
1. Pedicels slender 2
    2. Keel ciliate on the upper margins ..... *L. obtusilobus*
    2. Keel non-ciliate 3
3. Stems with some long-petioled lower leaves at flowering time..... *L. superbus* var.
3. Stems without long petioled lower leaves at flowering time..... *L. albicaulis* var.

*216. *L. Lyallii* Gray. Lyall's Lupine.—Common in sandy openings in Shasta Fir forests in the Canadian Zone where little else will grow, and above timberline between Squaw Valley and Mud Creeks.

*217. *L. obtusilobus* Heller. Silvery Lupine.—Common. Above 7000 feet on the southwest slopes, at least, this species forms great silvery mats by itself or in association with *Chrysothamnus Bloomeri*. It rarely goes above the middle of the Hudsonian Zone. It is our commonest Lupine and one of our commonest herbs.

218. *L. superbus* Hel. var. *elongatus* C. P. Smith.—A small colony of this striking species grows near the head of the Bear Springs meadow.

*219. *L. albicaulis* Dougl. var. *shastensis* C. P. Smith. Shasta Lupine.—This lupine is found in the chaparral below Howard, up to Bear Springs, and in scattered colonies up to the Canadian Zone. In the Canadian Zone it forms a belt between the ridges north and south of Horse Camp. On the ridges

this belt extends up to 8000 feet to the south and 7800 feet to the north, while in the basins between it may drop to 7500 feet such as at the location where the Sisson Southern Trail passes through it.

Trifolium L., Clovers

1. Heads with an involucre ..... *T. involucratum* var.
1. Heads without an involucre 2
2. Flowers pedicellate 3
2. Flowers sessile 4
3. Annuals, flowers yellow, reflexed in age ..... *T. dubium*
3. Perennials, flowers white or pinkish ..... *T. repens*
4. Heads sessile, subtended by the stipules of the sessile upper leaves.... *T. pratense*
4. Heads long pedunculate ..... *T. longipes*

220. *T. involucratum* Ort. var. *fimbriatum* McDer. Owl Clover.—Forms a large and conspicuous part of the herbage along the creeks at Bear Springs. Also occurs locally at wet places and springs below.

221. *T. dubium* Sibth. Shamrock.—Several plants are established at Bear Springs.

222. *T. repens* L. White Clover.—Several plants are established at Bear Springs and at Horse Camp.

223. *T. pratense* L. Red Clover.—Several plants are established at Bear Springs.

224. *T. longipes* Nutt. Long-Stemmed Clover.—Occasional at Wagon Camp and Bear Springs and at wet places between them.

Lotus L., Bird's Foot Trefoil

1. Corolla white or cream-colored, veined or suffused with rose or red..... *L. americanus* var.
1. Corolla yellow, variously marked with rose, red or purple..... *L. obtusifolius* var.

*225. *L. americanus* (Nutt.) Bisch. var *minutiflorus* Ottley. Small-Flowered Spanish Clover.—Two small colonies have been seen, one in the chaparral above Bear Springs, and one in the chaparral along the lower part of the Sisson Southern Trail.

226. *L. obtusifolius* (Benth.) Greene var. *Torreyi* (Gray) Ottley.—Common in the meadow at Bear Springs, near the Municipal Spring, and in wet places between them.

Vicia L., Vetch

1. Herbage finely pilose pubescent, stems zig-zag ..... *V. californica*
1. Herbage glabrous or nearly so, stems straightish..... *V. americana*

227. *V. californica* Greene. California Vetch.—Common at Wagon Camp, MacBride Springs, along the road below MacBride Springs and in the chaparral near the Municipal Spring.

*228. *V. americana* Muhl. Common Vetch.—Common at Wagon Camp, Bear Springs and near the Municipal Spring in the dryer portions of woodlands around them.

Lathyrus L., Pea

1. Leaflets linear, equalling or exceeding the rachis ..... *L. graminifolius*
1. Leaflets shorter than the rachis, more or less truncate ..... *L. nevadensis*

229. *L. graminifolius* White.—Common at MacBride Springs, Wagon Camp, and below.

230. *L. nevadensis* Wats.—In general the range of the two Vicias and the two Lathyrus species coincides. This species is common at MacBride Springs, Wagon Camp, and other moist places in the Transition Zone.

30. LINACEAE, Flax Family

1. Perennials, styles 5 ..... *L. Lewisii*
1. Annuals, styles 3 ..... *L. micranthum*

*231. *L. Lewisii* Pursh. Blue Flax.—Occasional at Wagon Camp and below it on the road to Bear Springs. Also in the flat above Panther Creek Meadows.

232. *L. micranthum* Gray. Small Flax.—A small colony was observed on the Sisson Southern Trail in the chaparral at about 4500 feet and a few plants were noted near the Municipal Spring in the chaparral.

31. GERANIACEAE, Geranium Family

233. *Erodium cicutarium* L'Her. Red Stemmed Filaree.—Established at MacBride Springs.

32. POLYGALACEAE, Milk Wort Family

234. *Polygala cornuta* Kell. Milkwort.—Scattered throughout the chaparral and extending up into the Transition Zone forest.

33. EUPHORBIACEAE, Spurge Family

235. *Euphorbia serpyllifolia* Pers. Thyme-leaved Spurge.—Common in the trails and roadways around the lower limits of our area.

34. CELASTRACEAE, Burning Bush Family

236. *Pachystima myrsinites* Raf. Oregon Boxwood.—Occasional throughout the chaparral, especially below 4500 feet.

35. ACERACEAE, Maple Family

*237. *Acer glabrum* Torr. Sierra or Smooth Maple.—At the Sisson Southern Trail Spring, and along the trail below that point, at the same elevation in Cascade Gulch, and in the Alder thickets in Mud Creek Canyon.

36. RHAMNACEAE, Buckthorn Family

1. Fruit drupe-like, flowers inconspicuous ..... *Rhamnus*
1. Fruit a circumscissile capsule, flowers showy ..... *Ceanothus*

238. *Rhamnus californica* Esch. Coffee Berry.—Occasional. Scattered throughout the chaparral.

Ceanothus L., Buck Brush, Snow Brush, California Lilac

1. Leaves opposite, prostrate shrubs ..... *C. prostratus*
1. Leaves alternate, erect shrubs 2

2. Branchlets mostly flexible, spines none, leaves very broad.....*C. velutinus*
2. Branchlets mostly rigid, spinose or subspinose, leaves small 3
3. Capsules mostly crested .....*C. cordulatus*
3. Capsules mostly crestless .....*C. divaricatus*

*239. *C. prostratus* Benth. Mahala Mat.—Occasional throughout the chaparral and up into the Transition Zone forest.

*240. *C. velutinus* Dougl. Tobacco or Snow Brush.—One of the dominant members of the chaparral. In a smaller form it extends up exposed ridges to 7500 feet and in Diller Canyon to 8500feet.

*241. *C. cordulatus* Kell. Buck or Snow Brush.—Occasional throughout the chaparral, particularly at lower elevations.

242. *C. divaricatus* Nutt. Buck Brush.—Occasional throughout the chaparral especially at lower elevations.

37. Malvaceae, Mallow Family

1. Bractlets 3, distinct, inserted on the calyx .....*Malva*
1. Bractlets none or one and inserted on the base of the calyx .....*Sidalcea*

243. *Malva rotundifolia* L. Dwarf Mallow, Cheeses.—A small colony is established at Horse Camp.

244. *Sidalcea oregana* Gray. Spike Mallow.—A small colony is established at Bear Springs.

38. Hypericaceae, St. John's Wort Family

*245. *Hypericum anagalloides* C. & S. Tinker's Pennys, Dwarf St. John's Wort.—Common at Wagon Camp, particularly in the Sedge Swamp, and along the upper mossy portions of Squaw Valley and Panther Creeks, as well as in the springs on the west bank of Mud Creek Canyon.

39. Violaceae, Violet Family

Viola L., Violets

1. Flowers white, delicate plants of wet places .....*V. blanda*
1. Flowers yellow with purple color on the backs of the petals, plants common in dry woods and up to and above timberline.....*V. purpurea*

*246. *V. blanda* Willd. White Bog Violet.—Small colonies are to be found in the upper Wagon Camp meadow, at Panther Creek and Squaw Valley Creek meadows, and along spring creeks on the west bank of Mud Creek Canyon.

*247. *V. purpurea* Kell. Mountain Violet.—Common throughout the Canadian and Hudsonian Zones. It grows most luxuriantly in shaded places in the deeper Shasta Fir forests, is also found in sandy openings in that forest, and on the lava slopes above it up to 9500 feet, as on the banks of Mud Creek Canyon.

40. Loasaceae, Loasa Family

248. *Mentzelia albicaulis* Dougl. White-Stemmed Mentzelia.—Found in one place in the chaparral along the Sisson Southern Trail near a creek which flowed nearly to the Sacramento River in 1937. The creek, an extension of

Cascade Gulch, has been dry since then below 7000 feet during the growing season and this may account for the temporary appearance of the 1937 colony.

41. ONAGRACEAE, Evening Primrose Family

1. Flower parts in 2's ..... *Circaea*
1. Flower parts in 4's or 5's 2
2. Ovary 2-celled, calyx limb divided down to the ovary ..... *Gayophytum*
2. Ovary 4-celled, calyx tube produced above the ovary 3
3. Seeds naked ..... *Godetia*
3. Seeds with a tuft of hairs at one end ..... *Epilobium*

249. *Circaea pacifica* Asch. & Mag. Enchanters Nightshade.—A small colony was found near a spring on the west bank of Mud Creek Canyon.

*250. *Gayophytum ramosissimum* T. & G.—One of our commonest weeds. It attains a height of three to four feet in the lower chaparral in favorable years. It is also common in the lower Hudsonian Zone, where, around Horse Camp, it occurs in large patches of individuals about 6 inches high.

251. *Godetia quadrivulnera* (Dougl.) Spach.—Locally common in the chaparral especially at about 4500 feet along the Sisson Southern Trail, and near the Municipal Spring.

Epilobium L., Willow Herb

Key contributed by P. A. Munz

(Included in this key are two sepcies listed in the appendix as having been reported by Merriam but not collected since 1898.)

1. Hypanthium not prolonged beyond the ovary; flowers large, the petals 1-2 cm. long, entire, spreading ..... *E. angustifolium*
1. Hypanthium prolonged above the ovary; flowers usually smaller, the petals ascending 2
2. Flowers large, the petals 14-20 mm. long; stigma evidently lobed ..... *E. obcordatum*
2. Flowers smaller, the petals 2-12 mm. long; stigma usually long 3
3. Annuals, stems with exfoliating epidermis. Plants of dry situations ..... *E. paniculatum*
3. Perennials; epidermis not exfoliating. Mostly in moist situations 4
4. Rootstocks bearing turions (globose or ovoid winter buds with fleshy overlapping scales, which may be rather loose in *E. glandulosum*) 5
4. Rootstocks not turioniferous 6
5. Flowers rather large, the petals 5-10 mm. long; stems simple to divaricately branched ..... *E. glandulosum*
5. Flowers smaller, the petals 2-5 mm. long; the stems simple ..... *E. brevistylum*
6. Plant palid, glaucous and glabrous almost throughout ..... *E. glaberrimum*
6. Plant not glaucous but green or canescent 7
7. Stems 1-3 dm. tall, simple above, with few pairs of opposite leaves 8
7. Stems 3-10 dm. tall, usually freely branched, especially above; many of the upper leaves alternate; innovation by rosettes; petals 2-6 mm. long, white to purplish; inflorescence glandular pubescent ..... *E. adenocaulon*
8. Leaves sessile, oblong or linear, suberect; stems slender ..... *E. oregonense*
8. Leaves more or less distinctly petioled and spreading 9
9. Plant densely caespitose, stoloniferous; stems sigmoidly bent, 1-1.5 dm. tall; petals purplish to rose-colored, 4-6 mm. long; leaves 1-2 cm. long 10
9. Plant not so densely caespitose; stems erect, 1-3 dm. tall, leaves 1.5-5 cm. long 11
10. Capsule linear, slender, 1 mm. or less thick, 2-4 cm. long; seeds smooth, buds nodding ..... *E. alpinum*
10. Capsule subclavate, stouter, 1.5-2 mm. thick, 2-2.5 cm. long; seeds papillose, 1.5-2 mm. long; buds erect ..... *E. clavatum*

11. Petals purplish, 5-8 (12) mm. long; seeds papillose, 1 mm. long ..... *E. Hornemannii*
11. Petals white or pink tipped, ca. 3 mm. long; seeds smooth, 1 mm. long ..... *E. lactiflorum*

*252. *E. angustifolium* L. Fireweed.—Common through the chaparral and up into the Transition Zone forest.

253. *E. paniculatum* Nutt.—Two forms are recognized:

253a. *E. paniculatum* f. *adenocaulon* Hausskn.

253b. *E. paniculatum* f. *subulatum* Hausskn.—Both of which occur in the chaparral along the lower end of the Sisson Southern Trail.

254. *E. glandulosum* Lehm.—A large clump grows above the outlet of the Municipal Spring above Howard. In addition a variety is recognized:

254a. *E. glandulosum* var. *exaltatum* (Drew) Munz.—In the meadow at Bear Springs.

*255. *E. brevistylum* Barbey.—Several plants were found at Wagon Camp. In addition two varieties are recognized:

255a. *E. brevistylum* var. *subfalcatum* (Trel.) Munz.—Occasional in the Bear Springs meadow along the creeks.

255b. *E. brevistylum* var. *ursinum* Jepson.—Occasional in the Bear Springs meadow.

256. *E. glaberrimum* Barbey.—Common along the streams in Bear Springs and Wagon Camp meadows, and along a spring on the west bank of Mud Creek Canyon.

257. *E. adenocaulon* Hausskn.—Collected once in the meadow at Bear Springs.

258. *E. alpinum* L.—A small collection was made at the west boreal spring above Panther Creek meadows at 9000 feet in the Hudsonian Zone.

259. *E. clavatum* Trel.—Apparently more common than the preceding. Common along the upper streams at Panther and Squaw Valley Creek Meadows, as well as in most of the boreal springs on the southwest slopes.

260. *E. Hornemannii* Reichenb.—Common at the upper end of the upper Wagon Camp spring creek. Also occasional in Panther Creek meadows.

261. *E. lactiflorum* Hausskn.—A small collection was made in the middle Squaw Valley Creek heather meadows.

42. Umbelliferae, Parsley Family

1. Fruit bearing prickles, bristles or tubercles 2
1. Fruit not prickly or tuberculate, sometimes hairy 3
2. Ribs none, fruit tuberculate, flowers yellow ..... *Sanicula*
2. Ribs present, fruit not tuberculate, flowers white ..... *Osmorhiza*
3. Ribs of the fruit not winged 4
3. Some or all of the ribs of the fruit winged 6
4. Oil tubes none ..... *Osmorhiza*
4. Oil tubes present 5
5. Leaflets entire, linear ..... *Carum*
5. Leaflets toothed or serrate, ovate ..... *Ligusticum*
6. Lateral ribs winged, leaves large, lobed and serrate ..... *Heracleum*
6. All ribs winged, leaves small, finely discected ..... *Cymopterus*

262. *Sanicula tuberosa* Torr. Turkey Pea.—Common in the dry places between Bear Springs and Wagon Camp.

*263. *Osmorhiza nuda* Torr. Sweet Cicely.—Common at Bear Springs and occasional at Wagon Camp in the meadows. Merging into the variety:

263a. *O nuda* var. *brevipes* Jepson.—A few individuals occur along the upper Wagon Camp streams.

*264. *Carum Gairdneri* Gray. Squaw Root.—Common in the upper Wagon Camp meadow, the Wagon Camp sedge swamp, and the lower Wagon Camp meadow. Scattered through the moister places toward Bear Springs.

*265. *Ligusticum Grayi* C. & R. Gray's Lovage.—Common in the upper meadows at Panther and Squaw Valley Creeks. Occasional in a larger size from Wagon Camp through the moister places toward Bear Springs. Also in the springs in the South Gate.

*266. *Heracleum lanatum* Michx. Cow Parsnip.—Common in the meadow at Bear Springs.

*267. *Cymopterus terebinthinus* (Hook.) T. & G.—Collected on a ridge south of the lava flow on the north side of Shastina in a grove of *Cercocarpus ledifolius* in the Hudsonian Zone. A colony of larger plants was found on the lava flow north of Cascade Gulch above MacBride Springs.

43. CORNACEAE, Cornel or Dogwood Family

Cornus L., Dogwood

1. Flowers in a dense head subtended by a series of white, showy bracts.....*C. Nuttallii*
1. Flowers in an open compound cyme, involucre absent.....*C. californica*

*268. *C. Nuttallii* Aud. Western Flowering Dogwood.—Occasional bushes occur along a dry creek at 4500 feet on the Sisson Southern Trail. Also at the Municipal Spring.

*269. *C. californica* C. A. Mey. Creek Dogwood.—Clumps of bushes occur at Bear Springs, near the Municipal Spring and near the springs in Mud Creek Canyon.

44. ERICACEAE, Heather Family

1. Herbs, petals free from each other, except in one saprophytic species, anthers not awned 2
1. Shrubs, petals united 8
2. Plants with evergreen leaves 3
2. Plants without green leaves, saprophytes 4
3. Stems leafy, style short .....*Chimaphila*
3. Leaves basal, style elongated .....*Pyrola*
4. Ovary 1-celled .....*Pleuricospora*
4. Ovary 4-7 celled 5
5. Corolla none, stems streaked red and white .....*Allotropa*
5. Corolla present, stems not so streaked .....*Pterospora*
6. Ovary wholly inferior .....*Vaccinium*
6. Ovary wholly superior 7
7. Fruit a berry, anthers awned .....*Arctostaphylos*
7. Fruit a capsule, anthers awnless 8
8. Corolla saucer-shaped, with 10 pockets holding the anthers.....*Kalmia*
8. Corolla open-campanulate, without pockets .....*Phyllodoce*

Chimaphila Pursh, Pipsissewa

1. Leaves oblanceolate, many, peduncles 3-6 flowered ..... *C. umbellata*
1. Leaves ovate, few, peduncles 1-3 flowered ..... *C. Menziesii*

270. *C. umbellata* Nutt. Prince's Pine.—Common in the Canadian and Transition Zone forests along the Sisson Southern Trail and east to Mud Creek Canyon.

*271. *C. Menziesii* Spreng.—With *C. umbellata* but less frequent.

Pyrola L., Wintergreen

1. Plants saprophytic in habit ..... *P. aphylla*
1. Plants with chlorophyll, not saprophytic 2
2. Stigma peltate, without ring or collar ..... *P. secunda*
2. Stigma 5-lobed, subtended by a distinct ring or collar 3
3. Stigma with narrow erect or spoke-like lobes ..... *P. picta*
3. Stigma short oblong, sometimes much reduced ..... *P. dentata* var.

272. *P. aphylla* Sm.—Occasional in the Transition Zone along the Sisson Southern Trail.

*273. *P. secunda* L.—Occasional in the Transition and Canadian Zones and extending up various ridges to the Hudsonian Zone.

*274. *P. picta* Sm. White-Veined Shin Leaf.—Common along the Sisson Southern Trail in the Transition Zone and extending in scattered colonies to the Canadian Zone. Common in the bottom of Mud Creek Canyon.

*275. *P. dentata* Sm. var. *integra* Gray.—Occasional along the Sisson Southern Trail in the Transition Zone and common around the Sisson Southern Trail spring, as well as at springs on the west bank of Mud Creek Canyon.

*276. *Pleuricospora fimbriolata* Gray. Pine Drops.—A few patches occur in the Transition Zone along the Sisson Southern Trail. One colony was found in the upper Canadian Zone on the west bank of Mud Creek Canyon.

277. *Allotropa virgata* T. & G. Sugar Stick.—Scattered through the Canadian Zone. Grows particularly in rotten logs of *Abies magnifica* var. *shastensis*.

*278. *Pterospera andromeda* Nutt. Pine Drops.—Occasional in the pine forests of the Transition Zone on the southwest slopes, especially along the Sisson Southern Trail; common in the pine woods along Bolam Creek on the north side of the mountain common in the flats along the lower portion of Mud Creek Canyon; and occasional in the recent lava flow north of Cascade Gulch. Apparently always associated with *Pinus ponderosa*.

Vaccinium L., Huckleberry

1. Calyx 5-lobed or parted, leaves entire, only slightly veiny ..... *V. occidentale*
1. Calyx entire, as if truncate; leaves serrulate, reticulate veiny 2
2. Plants 2-4 feet high, leaves 1-2 inches long ..... *V. membranaceum*
2. Plants very low, leaves less than 1 inch long ..... *V. caespitosum*

*279. *V. occidentale* Gray. Western Blueberry.—A large patch grows around the sedge swamp at Wagon Camp.

280. *V. membranaceum* Dougl. Thin-leaved Huckleberry.—Collected once near Panther Creek meadows.

*281. *V. caespitosum* Michx. Dwarf Blueberry.—A dwarf forest, rarely more than 6 inches tall, occurs throughout Panther Creek meadows. Common throughout Squaw Valley and Panther Creek meadows in association with *Phyllodoce* and *Kalmia*.

Arctostaphylos Adans., Manzanita

1. Erect, robust shrubs 4-8 or more feet high ..... *A. patula*
1. Procumbent or low shrubs, plants forming a rough mat usually less than 1 foot high ..... *A. nevadensis*

*282. *A. patula* Greene. Green Manzanita.—The chief component of the chaparral extending around the mountain, up in Diller Canyon to 8500 feet, and up on exposed ridges on the southwest slopes to 7500 feet. Also isolated bushes are found in the lower part of the Shasta Fir forest.

*283. *A. nevadensis* Gray. Pine Mat Manzanita.—The chief, and usually the only, shrub or understory in the Canadian Zone forest of Shasta Fir. It forms mats rarely more than 1-1½ feet tall and of wide circumference. It covers barren slopes and ridges and extends to the Hudsonian Zone to the same height, but not above, *Pinus albicaulis*, in places. On upper ridges in the Hudsonian Zone it is co-dominant with *Castanopsis sempervirens* and sometimes *Holodiscus discolor*. Along the Sisson Southern Trail, and more commonly in Mud Creek Canyon, it is associated with *A. patula* in open Transition Zone forest floors.

*284. *Kalmia polifolia* Wag. Pale or Bog Laurel.—The heather meadows of Squaw Valley and Panther Creeks are made up of three speices of dominant low shrubs including this species, *Phyllodoce* and *Vaccinium caespitosum*. This is more abundant at Panther Creek. The aspect is tundra-like.

*285. *Phyllodoce empetriformis* (Sm.) Don. Red Heather, Bryanthus.—One of the three dominants of the Heather Meadows. It also occurs throughout the subalpine zone, including the Hudsonian, at any place on the mountain where there is the slightest indication of surface or subsurface water. The most obvious of these places are in the vicinity of the boreal springs on the southwest sides of the mountain. In one place it is replaced by *Lutkea pectinata* as reported under that species.

45. PRIMULACEAE, Primrose Family

286. *Trientalis europea* L. var. *latifolia* Torr. Star Flower.—Colonies occur at MacBride Springs, at 4500 feet along the Sisson Southern Trail in the chaparral, and near the Municipal Spring.

46. GENTIANACEAE, Gentian Family

*287. *Gentiana simplex* Gray. One-flowered Gentian.—Frequent in the sedge swamp at Wagon Camp.

47. APOCYNACEAE, Dogbane Family

1. Style very short, corolla tube with 5 small appendages alternate with the stamens ..... *Apocynum*
1. Style filiform, corolla tube with a minute appendage behind each stamen.... *Cycladenia*

*288. *Apocynum androsaemifolium* L. var. *pumilum* Gray. Mt. Hemp.—

Common throughout the chaparral and occasional in the Transition Zone forest.

*289. *Cycladenia humilis* Benth. Lamb's Horns.—Locally abundant in large colonies on exposed ridges facing the south in the Hudsonian and Canadian Zones. In one location near Mud Creek Canyon nearly an acre of ground is completely covered with this species.

48. Polemoniaceae, Phlox Family

1. Calyx growing with the capsule, not ruptured by it 2
1. Calyx ruptured by the growing capsule 3
2. Leaves simple, annuals ..... *Collomia*
2. Leaves compound, alpine perennial ..... *Polemonium*
3. Corolla salverform, the tube contracted at the throat ..... *Phlox*
3. Corolla funnelform to salverform or campanulate, throat not contracted 4
4. Calyx lobes unequal, pungent ..... *Navarretia*
4. Calyx lobes equal, not pungent 5
5. Leaves pinnate or bipinnate, alternate above ..... *Gilia*
5. Leaves simple, opposite ..... *Linanthus*

Collomia. Nutt., Glue-seed

1. Stamens equally inserted on the corolla throat but of unequal length ..... *C. tinctoria*
1. Stamens unequally inserted in the corolla tube ..... *C. grandiflora*

290. *C. tinctoria* Kell.—A small colony was found in the bed of Mud Creek Canyon.

*291. *C. grandiflora* Dougl.—Common throughout the chaparral between and below Bear and MacBride Springs.

*292. *Polemonium shastense* Eastwood. Shasta Jacob's Ladder.—Occasional on lava ridges above 9,000 and reported extending up to 12,000 feet. An isolated colony occurs at 8000 feet in Horse Camp Creek, another at 8200 feet on the north side of Red Butte, and another on the west bank of Mud Creek Canyon. These three, and other colonies, occur in the *Pinus albicaulis*, or Hudsonian, zone.

Phlox L., Phlox

1. Annual, corolla limb narrow ..... *P. gracilis*
1. Perennial, corolla limb broad ..... *D. Douglasii*

293. *P. gracilis* (Hook.) Greene.—A small colony grows in the dryer portions of Bear Springs meadow.

*294. *P. Douglasii* Hook.—Occasional along the road and in the chaparral and forest below Wagon Camp. Common in the lava flats in the Canadian and Hudsonian Zones, especially in the one between Wagon Camp and Panther Creek, and around Horse Camp. It also extends up the ridges in the Hudsonian Zone above timberline.

295. *Navarretia prolifera* Greene.—Common in large mats in open places between Wagon Camp and Bear Springs.

*296. *Gilia aggregata* (Pursh) Spreng. Scarlet Gilia, Skyrocket.—Occasional in the chaparral, at MacBride Springs, above Wagon Camp, and around and below Horse Camp.

297. *Linanthus Harknessii* (Curran) Greene.—Found in one colony in an open place below Wagon Camp.

49. HYDROPHYLLACEAE, Phacelia Family

1. Stamens equal, style 2-cleft at the apex ..... *Phacelia*
1. Stamens unequal, styles distinct from the base ..... *Nama*

Phacelia Juss.

1. Strictly erect, coarse plants of the chaparral ..... *P. californica* var.
1. Plants not strictly erect but branching from the base 2
2. Low mat forming plants of above timberline, the mat being formed by innumerable branches from a large deep root ..... *P. frigida*
2. Plants sometimes low, but not mat forming as above; in the forest or upper chaparral 3
3. Plants of the Transition Zone ..... *P. leucophylla*
3. Plants of the Hudsonian and Canadian Zones ..... *P. mutabilis*

298. *P. californica* Cham. var. *virgata* (Greene) Jepson.—Common in the chaparral at the lower limits of our area.

*299. *P. frigida* Greene. Alpine Phacelia.—Occasional as large mats between 9000 and 10,000 feet. Occasionally seen below the upper limits of *Pinus albicaulis*.

300. *P. mutabilis* Greene.—Common just above and below Wagon Camp in the dry open forest, in Mud Creek Canyon, and on the ridges and slopes in the vicinity of Horse Camp.

301. *P. leucophylla* Torr.—Common in the dry open meadow at MacBride Springs.

302. *Nama Lobbii* Gray.—Common in large mats throughout the chaparral. Also at isolated stations in the Canadian Zone such as one of the cuts on the Everett Memorial Highway at about 7000 feet.

50. BORAGINACEAE, Borage Family

1. Nutlets armed with barbed prickles 2
1. Nutlets unarmed or tuberculate 4
2. Nutlets thin and flat, annuals ..... *Pectocarya*
2. Nutlets globose or thick, annuals or perennials 3
3. Nutlets spreading, prickly all over, perennials ..... *Cynoglossum*
3. Nutlets erect, not prickly all over, annuals ..... *Hackelia*
4. Nutlets erect, attached from the base to the middle ..... *Cryptantha*
4. Nutlets oblique or incurved, attached above the base ..... *Plagiobotrys*

303. *Pectocarya pusilla* (DC.) Gray.—Immature material was collected near Bear Springs and referred to this species.

304. *Cynoglossum occidentale* Gray. Western Hound's Tongue.—Occasional throughout the chaparral.

*305. *Hackelia californica* (Gray) Johnston. Stick-Tight.—Common at Wagon Camp, Bear Springs, MacBride Springs, and Mud Creek Canyon, and moist places between them in the Transition Zone. Extends up the Sisson Southern Trail to 6500 feet, and up the Horse Camp-Wagon Camp Trail to 6000 feet.

*306. *Cryptantha affinis* (Gray) Greene.—Common at Wagon Camp and Bear Springs.

307. *Cryptantha simulans* Greene.—Collected once near MacBride Springs.

308. *Plagiobotrys hispidus* Gray.—Small colonies occur near the Sisson Southern Trail Spring and near the Municipal Spring in dry places along trails.

51. Labiatae, Mint Family

1. Calyx 2-lipped, the lips entire ..... *Scutellaria*
1. Calyx regular or 2-lipped, the lips not entire 2
2. Corolla regular or nearly so ..... *Monardella*
2. Corolla markedly 2-lipped 3
3. Calyx with 10 spinescent teeth hooked at the tip ..... *Marubium*
3. Calyx teeth not hooked at the tip 4
4. Upper calyx lip truncate, flowers in a dense spike ..... *Brunella*
4. Upper calyx lip not truncate 5
5. Fertile stamens 2, calyx teeth unequal ..... *Salvia*
5. Fertile stamens 4, calyx teeth equal ..... *Stachys*

*309. *Scutellaria nana* Gray. Dwarf Skull Cap.—One small colony was found in a canyon bottom south of the lava flow on the north side of Shastina in the Hudsonian Zone.

*310. *Monardella odoratissima* Benth. Penny Royal.—A few plants are scattered through the chaparral. The species becomes more common as it ascends the mountain where in the near-timberline flats at Horse Camp it forms large masses.

311. *Marrubium vulgare* L. Common Horehound.—Several individuals are established along the road above Howard.

312. *Brunella vulgaris* L. Self Heal.—Well established, and locally common, in moist places from Bear Springs to Wagon Camp.

313. *Salvia sonomensis* Greene. Creeping Sage.—Commonly found in large mats in the chaparral north of the McCloud River Railroad tracks.

314. *Stachys rigida* Nutt. ssp. *rivularis* (Heller) Epling. Hedge Nettle.—Common in the creeks at Wagon Camp and Bear Springs.

52. Solanaceae, Nightshade Family

315. *Chamaesaracha nana* Gray. Dwarf Nightshade.—In large colonies below Bear Springs in the chaparral, around Wagon Camp, in the sandy lava flat above Wagon Camp, and in a similar flat above Panther Creek meadows.

53. Scrophulariaceae, Figwort Family

1. Anther bearing stamens 5 ..... *Verbascum*
1. Fertile stamens 4 or 2 2
2. Stamens 5, 4 anther bearing, the 5th. sterile and often rudimentary 3
2. Stamens 4 or 2, the fifth entirely lacking 4
3. Annuals, middle lobe of lower lip of corolla folded lengthwise in a sac to enclose the stamens ..... *Collinsia*
3. Perennials, lobe not so folded ..... *Pentstemon*
4. Upper lip of corolla not galeate, leaves largely opposite 5
4. Upper lip of corolla galeate, leaves mostly alternate 6

5. Corolla 5-lobed, not rotate, stamens 4 ..... *Mimulus*
5. Corolla 4-lobed, rotate, stamens 2 ..... *Veronica*
6. Anther sacs alike, parallel ..... *Pedicularis*
6. Anther sac dissimilar, the inner one pendulous by its apex 7
7. Galea longer than the lower lip, calyx 2-cleft, mostly perennials ..... *Castilleja*
7. Galea not much exceeding the lower lip, calyx equally 4-cleft, annuals ..... *Orthocarpus*

316. *Verbascum thaspus* L. Common Mullein.—Established at Bear and MacBride Springs.

317. *Collinsia parviflora* Dougl. Small-flowered Blue-Eyed Mary.—A small colony occurs in a moist area above Bear Springs.

Pentstemon Mitch., Beard-Tongue

1. Leaves ashy-gray, rough but not hairy ..... *P. cinereus*
1. Leaves bright green, smooth 2
2. Anther cells horse-shoe shaped or saggitate ..... *P. gracilentus*
2. Anther cells joined at the apex, soon spreading or divaricate 3
3. Anthers densely long-wooly 4
3. Anthers sometimes hairy but never densely long woolly 5
4. Corolla blue or lavendar, leaves mostly entire ..... *P. Menziesii* var.
4. Corolla crimson, leaves mostly serrate ..... *P. Newberryi*
5. Flowers 1-1½ inches long, borne in strict racemose panicles ..... *P. speciosus*
5. Flowers less than 1 inch long, in more or less whorl-like glomerules 6
6. Leaves entire, corolla blue ..... *P. procerus*
6. Leaves dentate, corolla yellowish ..... *P. deustus* ssp.

318. *P. cinereus* Piper.—A small specimen was collected on the bank of Bolam Creek in the Transition Zone forest.

*319. *P. gracilentus* Gray.—Common around Horse Camp where several pure white individuals occur. More occasional up the north ridge and down into the lower Canadian Zone.

320. *P. Menziesii* Hook. var. *Davidsonii* (Greene) Piper.—Common around the mountain in boreal areas, including the Hudsonian Zone. Found wherever there appears to be subsurface water which never quite becomes a spring. Along the Summit Trail to nearly 10,000 feet.

*321. *P. Newberryi* Gray. Mountain Pride.—Common on rock outcroppings in the upper Transition Zone and down into the chaparral. Also on rock outcroppings, but less common, throughout the Canadian Zone to timberline.

*322. *P. speciosus* Dougl.—Scattered throughout the chaparral; found along the road below MacBride Springs, and in canyons on Shastina such as Diller Canyon and one of the canyons south of the lava flow on the north side of Shastina.

323. *P. procerus* Dougl. ex Grah —Common in a colony below Wagon Camp and scattered down nearly to Bear Springs in moist places. Also frequent in the Panther Creek heather meadows.

*324. *P. deustus* Dougl. ssp. *typicus* Keck.—Common on the lava outcropping along the Sisson Southern Trail at 4500 feet and up to the edge of the forest along that trail.

Mimulus L., Monkey-Flower

1. Corolla regular to slightly 2-lipped 2
1. Corolla strongly 2-lipped 5
2. Capsule not splitting at apex 3
2. Capsule with supra-placental tissue splitting at apex 4
3. Herbage with evident pubescence, slimy ..... *M. moschatus*
3. Herbage apparently glabrous ..... *M. pulsiferae*
4. Annuals, flowers short pediceled, purple ..... *M. rubellus*
4. Perennials, flowers with long, slender pedicels, yellow ..... *M. primuloides*
5. Plants with basal as well as cauline leaves ..... *M. guttatus*
5. Plants with cauline leaves only ..... *M. implexus*

325. *M. moschatus* Dougl. Slimy Monkey-Flower.—Occasional plants grow along the Bear Springs Creeks and a large colony was found near the small spring above Bear Springs along the road to Wagon Camp.

326. *M. pulsiferae* Gray.—Common in large quantities in the dryer areas between Wagon Camp and Bear Springs and in a one-flowered form near the upper end of Squaw Valley Creek.

327. *M. rubellus* Gray.—Purple Monkey-Flower.—Same range as *M. pulsiferae* except that a small colony was observed near a sand flat along the Horse Camp lane.

*328. *M. primuloides* Benth.—Common in moist places almost all over the southwest slopes. Not found below Bear Springs or north of the McCloud River Railroad, as yet. Occurs from Bear Springs at 5000 feet in the Transition Zone to the boreal springs at more than 9000 feet in the Hudsonian Zone.

329. *M. guttatus* DC. Monkey-Flower.—Common along the spring creeks above Bear Springs, at Bear Springs, below Bear Springs, at Wagon Camp and at MacBride Springs as well as in Mud Creek Canyon.

330. *M. implexus* Greene.—Common in all the springs and upper portions of Squaw Valley and Panther Creek meadows in the boreal areas. In the springs in the South Gate one cannot see the water in most parts of the short creeks because of the dense mat of herbage produced by this species.

Veronica L., Speedwell

1. Capsule elliptical, emarginate ..... *V. alpina*
1. Capsule more or less orbicular, obcordate ..... *V. serpyllifolia*

331. *V. alpina* L. var. *cascadensis* Fernald. Cascade Speedwell.—Common in the heather meadows in Squaw Valley and Panther Creeks and in the springs in the South Gate.

322. *V. serpyllifolia* L. Thyme-leaved Speedwell.—Common around the upper Wagon Camp Springs. Infrequent at the lower spring above Horse Camp.

333. *Pedicularis densiflora* Benth. Indian Warrior, Lousewort.—Common in the chaparral, especially just below MacBride Springs. Also seen along the road above Bear Springs.

Castilleja Mutis., Indian Paint Brush

1. Leaves cleft or divided ..... *C. arachnoidea*
1. Leaves mostly entire 2
2. Bracts much longer than the calyx ..... *C. miniata*
2. Bracts about equalling the calyx ..... *C. pinetorum*

*334. *C. arachnoidea* Greenm.—Common in the Hudsonian Zone lava flats in the vicinity of and just above timberline.

*335. *C. miniata* Dougl.—Common. Occurring as a dwarfed species in the heather meadows of Squaw Valley and Panther Creeks, where it gives a bright red or scarlet color to the landscape. It also occurs as a large bush-like plant, as high as three feet, on the open slopes in the Hudsonian Zone. Also at Bear Springs. A yellow variation occurs with the commonly red species.

336. *C. pinetorum* Fern.—Frequent throughout the chaparral.

337. *Orthocarpus imbricatus*. Torr. Owl's Clover.—A small colony was collected once in a meadow half way between Wagon Camp and Bear Springs.

54. Orobanchaceae, Broom-Rape Family

*338. *Boschniackia strobilacea* Gray.—Occasionally associated with both species of *Arctostaphylos*. Large individuals, which are very deeply rooted, are found with *A. patula* below MacBride Springs. Small individuals, usually shallowly rooted, are found with *A. nevadensis* throughout the Canadian Zone on the southwest slopes.

55. Plantaginaceae, Plantain Family

339. *Plantago lanceolata* L. Ribwort, English Plantain.—Several individuals are established at Bear Springs.

56. Rubiaceae, Madder Family

1. Leaves apparently in whorls ..... *Galium*
1. Leaves opposite ..... *Kelloggia*

Galium L., Beadstraw, Cleavers, Goose-Grass

1. Leaves 6-8 in a whorl ..... *G. aparine*
1. Leaves in whorls of 4's, or 5-6's, or reduced to 2's 2
2. Plants from slender or filiform roots 3
2. Plants from woody rootstocks 4
3. Upper leaves often reduced to 2 per whorl ..... *G. bifolium*
3. Upper leaves in whorls of 4-5 ..... *G. trifidum*
4. Flowers mostly in paniculate cymes ..... *G. Bolanderi*
4. Flowers mostly solitary on long peduncles in the leaf axils ..... *G. Nuttallii*

340. *G. aparine* L. Goose-Grass, Cleavers.—A rankly growing colony was found at MacBride Springs.

341. *G. bifolium* Wats.—Common in large patches in the vicinity of Wagon Camp.

342. *G. trifidum* L. Croup Weed.—Several colonies occur along the upper Wagon Camp Spring creek.

343. *G. Bolanderi* Gray.—Several scattered plants occur along the Sisson Southern Trail along the lava outcropping at 4500 feet.

344. *G. Nuttallii* Gray.—Range is the same as that for *G. Bolanderi.*

345. *Kelloggia galioides* Torr.—Common in the chaparral and upper Transition Zone forest. Occasional through the Canadian forest at least up to 7000 feet.

57. Caprifoliaceae, Honey-Suckle Family

1. Corolla regular, rotate, leaves compound ..... *Sambucus*
1. Corolla tubular to funnelform, leaves simple 2
   2. Berry snow-white ..... *Symphoricarpos*
   2. Berry red or black ..... *Lonicera*

Sambucus L., Elder Berry

1. Cymes flat topped, berry blue with a bloom ..... *S. caerulea*
1. Cymes dome shaped, berry red ..... *S. racemosa*

346. *S. caerulea* Raf. Blue Elderberry.—Common around MacBride Springs; several groves of bushes occur at the Municipal Spring and Bear Springs, and common in the canyon west of Bolam Creek on the north side of the mountain.

347. *S. racemosa* L. Red Elderberry.—Common on the south side of Red Butte and in the Alder thickets in Mud Creek Canyon.

Symphoricarpos Dill. Snow Berry

(Key to species by George Neville Jones)

1. Procumbent or trailing shrub; young twigs softly velutinous-pubescent with short, straight, spreading trichomes; leaves ovate, prominently reticulate and densely villosulous beneath; corolla short-campanulate, 4-5 mm. long, the lobes about as long as the tube; style 2-2.5 mm. long; fruits subglobose, 4-6 mm. in diameter ..... *S. acutus*
1. Erect shrub; young twigs finely grayish puberulent with short, curved trichomes; leaves oval, puberulent; corolla cylindrical-campanulate, 7-8 mm. long, the lobes about one-third the length of the tube; style 4 mm. long; fruits ellipsoid, about 1 cm. long ..... *S. vacinioides*

348. *S. vacinioides* Rydb. Wax Berry.—Several bushes were found on the north side of the mountain between Inconstance and Bolam Creeks in the Upper Canadian Zone.

349. *S. acutus* (Gray) Dieck. Snow Berry.—Occasional in the chaparral and along the Sisson Southern Trail at least up to the lower Canadian Zone.

350. *Lonicera conjugalis* Kell. Honeysuckle.—A small colony occurs along the spring creek above Bear Springs on the road to Wagon Camp in association with *Spiraea Douglasii.* Also several bushes occur in Mud Creek Canyon.

58. Campanulaceae, Bell-Flower Family

*351. *Campanula Wilkinsiana* Greene. Wilkins' or Shasta Blue Bell.—This species was first described from material collected by Miss Laura Wilkins, of the Merriam Expedition, at the upper end of Squaw Valley Creek. It is at present common the length of the meadows on this creek from 7500 to 8500 feet. It also grows in two of the boreal springs above Horse Camp, in Horse Camp Creek, and in springs along Mud Creek Canyon. Its zonal position is Upper Canadian and Hudsonian.

59. Compositae, Composite, Lettuce, or Sunflower Family

Key to Tribes

1. Flower of the head all ligulate plants usually with milky juice ..... 1. *Cichorieae*
1. Flowers not all ligulate, plants without milky juice 2
2. Anthers caudate at the base, rays none 3
2. Anthers not caudate at the base, rays present or absent 4
3. Anthers unappendaged at the tip, heads small, plants not prickly, involucral bracts usually white and scarious ..... 2. *Inuleae*
3. Anthers with elongated appendages at the tip, heads large, plants usually prickly on the involucres, leaves, or both ..... 3. *Cynareae*
4. Receptacle with chaffy bracts ..... 4. *Madieae*
4. Receptacle naked, without bristles or chaffy bracts 5
5. Style branches thickened upward, obtuse, the stigmatic lines not extending beyond the middle, flowers never yellow, heads discoid ..... 5. *Eupatorieae*
5. Style branches not thickened upward, stigmatic lines in perfect flowers extending to the summit 6
6. Involucral bracts well imbricated 7
6. Involucral bracts seldom well imbricated 8
7. Involucral bracts not usually dry or scarious, pappus of awns or bristles present ..... 6. *Astereae*
7. Involucral bracts dry and scarious, pappus reduced to a crown or ring or none ..... 7. *Anthemideae*
8. Pappus not capillary but of bristles, scales, awns or none, involucral bracts in 1-3 series ..... 8. *Helenieae*
8. Pappus of soft, capillary hairs, involucral bracts mostly in one series with some much shorter outer ones ..... 9. *Senecioneae*

Keys to Genera and Species

59-1. Cichorieae, Cichory or Lettuce Tribe

1. Pappus paleaceous ..... *Microseris*
1. Pappus of bristles 2
2. Pappus bristles plumose 3
2. Pappus bristles not plumose 4
3. Achenes beaked ..... *Tragopogon*
3. Achenes not beaked ..... *Stephanomeria*
4. Achenes flattened ..... *Lactuca*
4. Achenes not flattened 5
5. Achenes not beaked ..... *Hieracium*
5. Achenes distinctly beaked 6
6. Achenes 4-5 ribbed ..... *Agoseris*
6. Achenes 10-more ribbed ..... *Taraxacum*

352. *Microseris nutans* (Geyer) Sch. Bip.—Common in a small area below Wagon Camp in a chaparral opening.

353. *Tragopogon dubius* Scop. Salsify, Goat's Beard.—Common in the chaparral along the lower end of the Sisson Southern Trail.

Stephanomeria Nutt.

1. Perennials, achenes not tubercular ..... *S. lactucina*
1. Annuals, achenes irregularly rugose tubercular ..... *S. virgata*

*354. *S. lactucina* Gray.—Common in the lower chaparral along the Sisson Southern Trail, and along the Wagon Camp road. Occasional up into the Canadian Zone.

355. *S. virgata* Benth.—Occasional in the lower chaparral along the Sisson Southern Trail and the Wagon Camp Road.

356. *Lactuca scariola* L. Prickly Lettuce.—In a small colony near the terminus of the old wagon road from which the Sisson Southern Trail once started.

Hieracium L., Hawkweed

1. Flowers white ..... *H. albiflorum*
1. Flowers yellow 2
2. Stems leafy, at least below 3
2. Stems not at all or rarely leafy 4
3. Herbage tomentose with dense stellate pubescence ..... *H. Greenei*
3. Herbage with long shaggy gray or brown pubescence ..... *H. horridum*
4. Basal leaves glabrous, involucre with black pubescence ..... *H. gracile*
4. Basal leaves more or less hairy 5
5. Involucre glandular ..... *H. cynoglossoides*
5. Involucre not glandular ..... *H. Bolanderi*

*357. *H. albiflorum* Hook. White-Flowered Hawkweed.—Found in a small colony below Bear Springs, in a larger colony near the Municipal Spring along the old Wagon Camp Road, and scattered through Mud Creek Canyon.

*358. *H. Greenei* Gray. Greene's Hawkweed.—Common on the recent lava flow north of Cascade Gulch and above MacBride Springs.

*359. *H. horridum* Fries. Shaggy Hawkweed.—A colony of fairly large individuals grows in Cascade Gulch at about 7000 feet. Mostly this species is scattered through the Hudsonian Zone rock slopes in colonies of small individuals.

*360. *H. gracile* Hook. Slender Hawkweed.—Fairly common throughout the Hudsonian Zone around subalpine springs and scattered among the rocks.

*361. *H. cynoglossoides* Arv. var. *nudicaule* Gray.—Fairly common in the chaparral openings between Bear Springs and Wagon Camp.

362. *H. Bolanderi* Gray.—Common under rocks on ridges and in talus through the Hudsonian Zone. It occurs in large colonies or as single plants.

Agoseris Raf., False Dandelion

1. Annuals ..... *A. heterophylla*
1. Perennials 2
2. Achenes indistinctly beaked ..... *A. scorzoneraefolia*
2. Achenes distinctly beaked 3
3. Involucre equaling or exceeding the pappus ..... *A. grandiflora*
3. Involucre little exceeding the beaks of the achenes ..... *A. gracilens*

363. *A. heterophylla* (Nutt.) Greene.—Occurring in large colonies in rather moist places at Bear Springs and MacBride Springs.

364. *A. scorzoneraefolia* (Schrad.) Greene. Alpine Dandelion.—Scattered throughout the higher portions of the Hudsonian Zone. Common on several benches of lava near the upper limits of *Pinus albicaulis* between Horse Camp and Mud Creek Canyon. While the type locality of *A. monticola* Greene is this same general area Dr. Blake feels that revision of the genus will be necessary before these species can be more definitely separated from or lumped with *A. glauca*.

365. *A. grandiflora* (Nutt.) Greene.—Common, but scattered, throughout the chaparral.

366. *A. gracilens* (Gray) Ktze.—Common in one colony in the lowest meadow-like formation of Panther Creek meadows.

367. *Taraxacum officinale* Weber. Common Dandelion.—Established at Wagon Camp and Bear Springs.

59-2. INULEAE, Everlasting Tribe

1. Flowers all fertile ..... *Gnaphalium*
1. Flowers dioecious 2
2. Central flowers of pistillate head sterile, robust herb ..... *Anaphalis*
2. All flowers fertile in pistillate head, low herbs ..... *Antennaria*

Gnaphalium L., Cudweed

1. Involucre imbedded in loose wool, bracts scarcely conspicuous ..... *G. palustre*
1. Involucre woolly only at base, bracts conspicuous ..... *G. microcephalum*

368. *G. palustre* Nutt. Lowland Cudweed.—Found once at Bear Springs.

369. *G. microcephalum* Nutt. White Everlasting.—Occasional below Bear Springs and MacBride Springs espeically in the chaparral.

*370. *Anaphalis margaritacea* (L.) B. & H. Pearly Everlasting.—Common along springs on the west bank of Mud Creek Canyon and in the bottom of the canyon.

371. *Antennaria umbrinella* Rydb. Alpine Everlasting.—Common below the boreal springs on the southwest slopes and in dryer portions of Squaw Valley and Panther Creek meadows. Also extending to dry flats in the Shasta Fir forest below Horse Camp.

59-3. CYNAREAE, Thistle Tribe

372. *Cirsium lanceolatum* (L.) Scop. Bull Thistle.—Several plants are established along the Wagon Camp Road above Howard and below Bear Springs.

59-4. MADIEAE, Tarweed Tribe

Madia Mol., Tarweed

1. Perennials or biennials, pappus present in at least some flowers ..... *M. Bolanderi*
1. Annuals, pappus absent ..... *M. gracilis*

373. *M. Bolanderi* Gray.—Several plants occur at the edge of the Wagon Camp sedge swamp.

374. *M. gracilis* (Smith) Keck.—Found commonly throughout the chaparral in smaller individuals than those found in moist areas around Bear Springs and MacBride Springs.

59-5. EUPATORIEAE, Eupatory Tribe

375. *Eupatorium occidentale* Hook. Thoroughwort.—Common in three colonies: one on the bank of Cascade Gulch at 7000 feet, one in a canyon west of Bolam Creek on the north slope, and the other in Mud Creek Canyon.

59-6. ASTEREAE, Aster Tribe

1. Rays lacking ..... *Erigeron*
1. Rays present 2

2. Rays yellow 3
2. Rays white, pink, violet or purple 4
3. Stems herbaceous throughout ..... *Solidago*
3. Stems woody ..... *Chrysothamnus*
4. Involucre usually strongly graduated, rays usually comparatively broad ..... *Aster*
4. Involucre subequal, rarely somewhat graduated, rays usually narrow.... *Erigeron*

Erigeron L., Fleabane

1. Stems more or less scape-like, the leaves in a dense basal tuft ..... *E. compositus* var.
1. Stems leafy 2
2. Rays lacking ..... *E. inornatus*
2. Rays present 3
3. Lower leaves usually somewhat toothed ..... *E. canadensis*
3. Leaves all entire, plants of subalpine habit ..... *E. acris* var.

376. *E. compositus* Pursh var. *multifidus* (Rydb.) Macbr. & Pays. Alpine Daisy.—Found in scattered groups in the subalpine lava flats near Inconstance and Bolam Creeks, and in a large colony on the west side of Mud Canyon.

377. *E. inornatus* Gray. Pine Erigeron.—Common throughout the chaparral.

378. *E. canadensis* L. Horseweed.—Found in a small colony near the upper end of the short road from which the Sisson Southern Trail used to start.

379. *E. acris* L. var. *debilis* Gray.—A small colony was found on a lava outcropping at about 9500 feet on the ridge north of Horse Camp.

Chrysothamnus Nutt., Rabbit or Gold Brush

1. Heads discoid, herbage gray-tomentose ..... *C. nauseosus* var.
1. Heads radiate, herbage glabrous ..... *C. Bloomeri* var.

*380. *C. nauseosus* (Pall.) Britton var. *occidentalis* (Greene) Hall. Rabbit Brush.—Scattered throughout the chaparral, especially along the Sisson Southern Trail and MacBride Springs road, and reaching up the mountain in tongues of chaparral in Cascade Gulch and Diller Canyon as far as the Hudsonian Zone. Common in the Transition Zone forest on the recent lava flow north of Cascade Gulch.

*381. *C. Bloomeri* (Gray) Greene var. *angustatus* Gray. Gold Brush.—The dominant shrub of the Canadian zone lava flats where *Arctostaphylos nevadensis* is not established. Extending to the upper limits of the *Pinus albicaulis* zone and in scattered areas below the lava flat openings in the forest to the chaparral through which it is scattered. It also occurs along the old military highway in sandy openings where it dominates the understory. Above 7000 feet it is rarely more than one foot high and rather diffuse, while below 6000 feet it may reach a height of three feet.

*382. *Solidago elongata* Nutt. Goldenrod.—Scattered in moist places throughout the chaparral along the Wagon Camp road below 5200 feet.

Aster L., Aster

1. Involucral bracts ovate lanceolate ..... *A. occidentalis*
1. Involucral bracts linear and attenuate to spatulate 2
2. Herbage green, bright 3

2. Herbage somewhat gray 4
3. Leaves obovate to oblong or oblanceolate ..... *A. radulinus*
3. Leaves lanceolate to linear ..... *A. Fremontii*
4. Leaves mostly toothed ..... *A.* cf. *leucanthemifolius*
4. Leaves entire or nearly so ..... *A. shastensis*

383. *A. occidentalis* (Nutt.) T. & G. Western Aster.—Common in moist places around the subalpine springs above Panther Creek meadows and in The South Gate. Occasional through the heather meadows of Panther and Squaw Valley Creeks.

384. *A. radulinus* Gray. Purple Aster.—One large colony occurs above Howard along the Wagon Camp road.

385. *A. Fremontii* (T. & G) Gray. Fremont's Aster.—A small colony was found near the lower edge of the Wagon Camp sedge swamp.

386. *A.* cf. *leucanthemifolius* Greene. Blue Aster.—Material referred to this species was collected from a large colony along the MacBride Springs Road. It was also seen in the chaparral along the Sisson Southern Trail.

*387. *A. shastensis* Gray. Shasta Aster.—Scattered throughout the lava flats of the Hudsonian and Canadian zones above 6500 feet around the southwest slopes of the mountain.

59-7. ANTHEMIDEAE, Mayweed Tribe

1. Heads radiate ..... *Achillea*
1. Heads discoid ..... *Artemisia*

Achillea L., Yarrow

1. Plants of low elevations, erect ..... *A. lanulosa*
1. Plants of high elevations, prostrate ..... *A. lanulosa* var.

*388. *A lanulosa* Nutt. Lowland Yarrow.—Common at Wagon Camp, Bear Springs, MacBride Springs, and near the Municipal Spring. Occasional in the chaparral zetween.

388a. *A lanulosa* var. *alpicola* (Rydb.) Keck. Alpine Yarrow.—A large colony occurs at 9500 feet in the Hudsonian Zone along the west bank of Mud Creek Canyon.

Artemisia L., Sage Brush

1. Shrub, heads consisting of wholly perfect fertile flowers ..... *A. tridentata*
1. Perennial herbs, heads with marginal flowers pistillate, the central flowers perfect ..... *A. Douglasiana*

*389. *A. tridentata* Nutt. Common Sage Brush.—Collected once along the road leading to the base of the mountain around a red cinder cone south of Morrison. Possibly otherwise occasional within our limits along the south end of the Shasta Valley.

390. *A. Douglasiana* Besser.— One colony grows along the Wagon Camp Road in a creek bottom near Howard.

59-8. HELENIEAE, Sneezeweed Tribe

1. Heads discoid ..... *Chaenactis*
1. Heads radiate 2
2. Bracts of involucre erect ..... *Hulsea*
2. Bracts of involucre reflexed ..... *Helenium*

Chaenactis DC.

1. Plants of lower elevations with stems of inflorescence red and much branched.... *C. rubricaulis*
1. Plants of higher elevations with stems of inflorescence brownish and bearing few heads ..... *C. pumila*

391. *C. rubricaulis* Greene.—Occasional on the lava slopes and flats throughout the upper Canadian Zone on the southwest side of the mountain.

392. *C. pumila* Greene.—Occasional in the upper Hudsonian Zone of the southwest slopes, but common in this zone between Squaw Valley Creek and Mud Creek Canyon.

Hulsea T. & G., Alpine Sunflower

1. Plants merely glandular pubescent ..... *H. nana*
1. Plants woolly as well as glandular pubescent ..... *H. nana* var.

*393. *H. nana* Gray.—Common on the boreal lava slopes and benches in and above the *Pinus albicaulis* zone.

393a. *H. nana* var. *Larsenii* Gray.—Always found with the species. Occasional plants may be found which show features of both the species and the variety.

*394. *Helenium Bigelovii.* Bigelow's Sneezeweed.—Occasional along the lower Wagon Camp creeks where it is difficult to collect because sheep find it delicious.

59-9. SENECIONEAE, Groundsel Tribe

1. Leaves mostly opposite ..... *Arnica*
1. Leaves mostly alternate ..... *Senecio*

Arnica L., Gum Weed

1. Heads discoid ..... *A. viscosa*
1. Heads radiate 2
   2. Leaves short, broad ..... *A. mollis*
   2. Leaves long, narrower ..... *A. longifolia* var.

*395. *A. viscosa* Gray.—Common on the lava slopes in the Hudsonian Zone on the southwest side of the mountain. Apparently it grows only between Cascade Gulch and Mud Creek Canyon, there being fewer individuals at these limits of its range than occur at its apparent center between Horse Camp and Panther Creek.

396. *A. mollis* Hook.—Common along Squaw Valley and Panther Creek meadows.

*397. *A. longifolia* Eat. var.—Common in a spring on the west side of Mud Creek Canyon.

Senecio L., Groundsel

1. Stems with mostly many and nearly equal leaves ..... *S. triangularis*
1. Stems few-leaved, naked above or the upper leaves reduced 2
   2. Stems solitary, tall and simple ..... *S. aronicioides*
   2. Stems caespitose, few to several in tufts 3
3. Plants glabrous or early glabrate ..... *S. cymbalarioides*
3. Plants permanently tomentose or more or less glabrate 4
   4. Radical leaves oblong lanceolate to narrowly oblanceolate ..... *S. Howellii*
   4. Radical leaves ovate ..... *S. oreopolus*

*398. *S. triangularis* Hook.—Common at the lower end of Panther Creek, in a spring along the same valley midway to Wagon Camp, near the lower meadows of Squaw Valley Creek, and in a spring on the west side of Mud Creek Canyon.

399. *S. aronicioides* DC.—Common in a grove of *Pinus ponderosa* along the Sisson Southern Trail at 5000 feet, at Wagon Camp and in the chaparral openings below it, at Panther Creek in the lower portions of the meadow, and at the source of a small spring between Gray and Red Buttes at the head of East Panther Creek.

400. *S. cymbalarioides* Nutt.—Material found growing common in the canyons and flats near the lava flow on the north side of Shastina has been tentatively referred to this species.

401. *S. Howellii* Greene.—Rather common on tops of ridges north of Horse Camp and Cascade Gulch.

402. *S. oreopolus* Greenm.—A small colony was found at 9500 feet on the west bank of Mud Creek Canyon.

Appendix

The Merriam Expedition (13) reported a number of species from Mount Shasta which have not been collected on the mountain since 1900. Original collections will have to be studied carefully in order to determine whether or not names used for them were correctly applied. In several instances, at least, the normal range of species on the following list precludes the possibility of their having been found on the mountain. These include species known to be of strictly desert, seashore, or other types of habitat not found on the mountain.

1. *Agoseris monticola* Greene
2. *Antennaria Geyeri* Gray
3. *Antennaria media* Greene
4. *Arnica Merriamii* Greene
5. *Artemisia Ludoviciana* Nutt.
6. *Castilleja affinis* H. & A.
7. *Crepis intermedia* Gray
8. *Epilobium obcordatum* Gray
9. *Epilobium oregonense* Hausskn.
10. *Erigeron armeriaefolium* Turcz.
11. *Eriogonum polypodum* Small
12. *Fragaria bracteata* Heller
13. *Fragaria chiloensis* Duch.
14. *Lilium parvum* Kellogg
15. *Mimulus moniliformis* Greene
16. *Mimulus tilingii* Regel
17. *Oreastrum alpigenum* (Gray) Greene
18. *Sambucus melanocarpa* Gray
19. *Sarcodes sanguinea* Torr.
20. *Saxifraga bryophora* Gray
21. *Senecio canus* Hook.
22. *Stellaria crispa* C. & S.
23. *Vaccinium caespitosum* var. *arbuscula* Gray
24. *Veronica Cusickii* Gray

It is hoped that through more diligent search of accessible and inaccessible areas on the mountain at least some of these species, as well as others such as those reported by Brown, will be added to the main list.

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Shasta Alpine Lodge,
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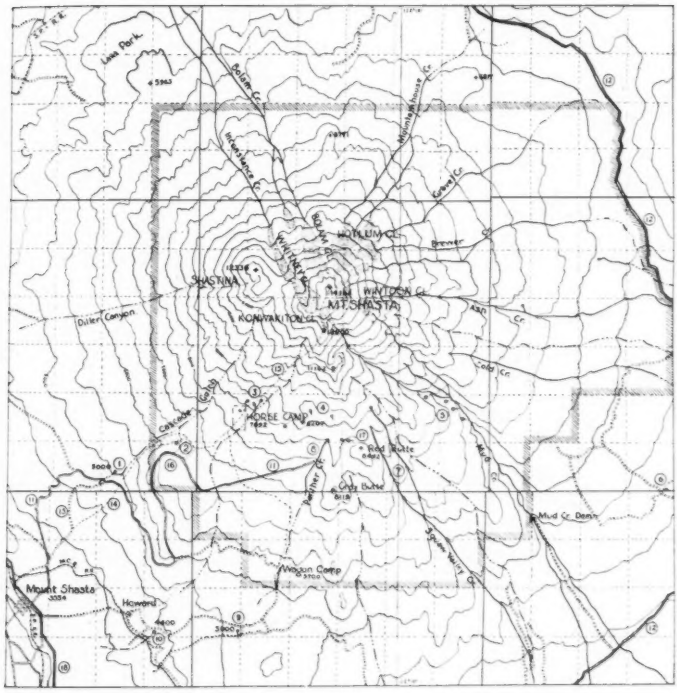
Siskiyou Co., Calif.

PLATE 1. Map of Mount Shasta



MOUNT SHASTA

— CALIFORNIA —

① MacBride Spring, ② Sisson Southern Trail Spring, ③ Horse Camp Springs, ④ Springs above Panther Creek, ⑤ Mud Creek Canyon Springs, ⑥ Widow Springs, ⑦ Squaw Valley Creek Meadow, ⑧ Panther Creek Meadow, ⑨ Bear Spring, ⑩ Municipal Spring, ⑪ John Everett Mem Highway, ⑫ Old Military Road, ⑬ MacBride Spring Road, ⑭ Sisson Southern Trail, ⑮ Summit Trail, ⑯ Sand Flats, ⑰ The Gate, ⑱ Pacific Highway (U.S. 99).

SCALE · MILES 1/62500 | CONTOUR INTERVAL 500 FT | BOUNDARY OF THE MOUNT SHASTA RECREATIONAL AREA.

COMPILED BY T. COBBE, JAN. 1940, FROM USDI, USGS - DUNSMUIR QUADRANGLE, CALIF., 1935; USDA, FOR. SER., SHASTA NATIONAL FOREST, CALIF., MT. DIABLO MER., 1931; FROM INFMN. SUPL'D BY WM B. COOKE.

PLATE 2

Fig. 1. Looking across expanses of chaparral to remnants of the Transition Zone forest. Mt. Shasta in the background. From the Wagon Camp road above Bear Springs.

Fig. 2. A chaparral covered lava outcropping near the Sisson Southern Trail showing remnants of the former forest.

Fig. 3. A shrub of *Chrysothamnus nauseosus* in the chaparral along the Sisson Southern Trail.

Fig. 4. A portion of the east wall of Mud Creek Canyon at a point where the canyon is 1500 feet deep. Rapid erosion is plainly in progress. *Pinus albicaulis* shrubs in the foreground and on the ridge across the canyon. Elevation app. 9,000 ft.

PLATE 3

Fig. 1. A remnant of the Transition Zone forest along the Wagon Camp road near Howard. The trees include *Pinus ponderosa*, *Libocedrus decurrens* and *Pseudotsuga taxifolia*. The prominent shrubs along the road are *Prunus emarginata*. 4,000 ft.

Fig. 2. *Pinus lambertiana* in the Transition Forest. 5,500 ft.

Fig. 3. *Abies magnifica* var. *shastensis* in the Canadian Zone forest. 7,500 ft.

Fig. 4. *Tsuga Mertensiana* in the Panther Creek heather meadows. Shasta Fir in the background. 7,800 ft.

Fig. 5. *Dicentra uniflora* on the lava flats at Horse Camp, 8,000 ft. Photo by Lloyd G. Ingles.

PLATE 4

Fig. 1. *Pinus albicaulis* wind timber on an exposed ridge near Panther Creek Meadows. 9,000 ft.

Fig. 2. *Pinus albicaulis* in a grove on a protected ridge above Squaw Valley Creek. Merriam's timberline appears as the highest mats of pine on the ridges in this view. App. 9,000 ft.

Fig. 3. *Tsuga Mertensiana* above the limits of timber producing forest which can be seen in the background. Above Panther Creek. App. 8,200 ft.

Fig. 4. *Ceanothus cordulatus* in the chaparral. App. 4,000 ft.

Fig. 5. *Ceanothus velutinus* at the edge of the Transition Zone forest. Seedlings of *Pinus Lambertiana* and *Abies concolor* in the background. 5,000 ft.

PLATE 5

Fig. 1. Detail of the forest floor in the Canadian Zone. *Stipa occidentalis*, *Lupinus obtusilobus*, *Chrysothamnus Bloomeri*, *Lupinus albicaulis* var. *shastensis* are present. The forest, at this point, is composed 100% of *Abies magnifica* var. *shastensis*. The blaze marks the Wagon Camp-Horse Camp Trail. App. 7,000 ft.

Fig. 2. An opening in the Shasta Fir forest. The ground in such an opening is covered with *Stipa* spp. and *Sitanion Hystrix*. App. 7,250 ft.

Fig. 3. A view across Wagon Camp to show the *Abies* forest which here is composed of both species of fir on the mountain. Transition-Canadian Zone. 5,700 ft.

Plate 6

Fig. 1. Looking over the upper meadow at Panther Creek from its source springs at about 8,000 ft. The forest border is composed of Shasta Fir and Mountain Hemlock. The meadow is composed of Heather, Laurel and Huckleberry. Canadian Zone.

Fig. 2. Looking up Squaw Valley Creek at the lower end of the middle heather meadow. Important species as for Panther Creek but *Pinus albicaulis* occurs as a tree in the grove in the center of the picture, and as a shrub-like plant on the ridges in the background. App. 8,000 ft.

Fig. 3. *Arnica viscosa* in a natural habitat on the ridge between Horse Camp and Panther Creek. App. 9,000 ft.

Plate 7

Fig. 1. The upper spring in The South Gate. *Mimulus implexus* fills the channel of the stream. On the banks the most abundant plant is *Carex spectabilis*. App. 8,200 ft.

Fig. 2. To show the sedge swamp area at Wagon Camp. The shrub is *Vaccinium occidentale*. The forest is made up of both species of *Abies* as well as *Pinus ponderosa*. 5,700 ft.

Fig. 3. The water supply spring above Horse Camp from the Summit Trail. Area of percolation is in the foreground; area of irrigation in the center of the picture. App. 8,100 ft.

Fig. 4. The upper of the three springs along the Summit Trail above Horse Camp. *Mimulus implexus* forms the abundant herbage in the foreground, while *Juncus Mertensianus* forms the borders. App. 8,250 ft.

Plate 8

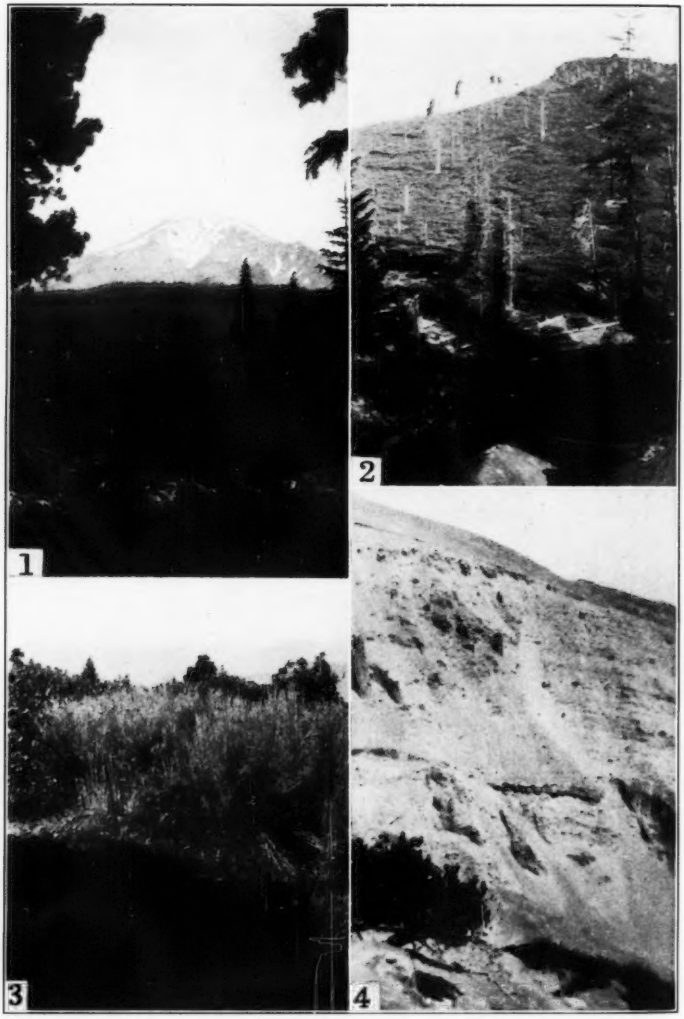
Fig. 1. View up Mud Creek Canyon from below timberline on the west bank. In the foreground in the Canadian Zone forest are Shasta Fir, Black Hemlock and Western White Pine. On the banks of the canyon below the forest groves in the middle background are thickets of Alder. The Canyon is 1,500 feet deep at most. Konwakiton, McCloud or Mud Creek Glacier is visible in the upper right hand corner, Thumb Rock is to the left of the glacier, while Castle Rock is at the lower end of Sargent Ridge at the left of the picture.

Fig. 2. Looking up the Summit Trail from the ridge south of Horse Camp. White-Bark Pines occur on knobs, like the one in the foreground, at their upper limits of growth around the mountain. App. 9,000 ft. July 29, 1938.

Fig. 3. An avalanche path between Horse Camp and Panther Creek. Timberline, as understood in this report, occurs at the upper edge of standing timber in this view. Shasta Fir dominates the scene but the ground cover is composed of *Arctostaphylos nevadensis*. App. 8,000 ft.

Fig. 4. A view up the ridges from the flats at Horse Camp. Shasta Fir dominates the flats, White Bark Pines the ridges. *Lupinus obtusilobus* is the silvery plant in foreground; the dark shrub in the right center is *Chrysothamnus Bloomeri*.

PLATE 2



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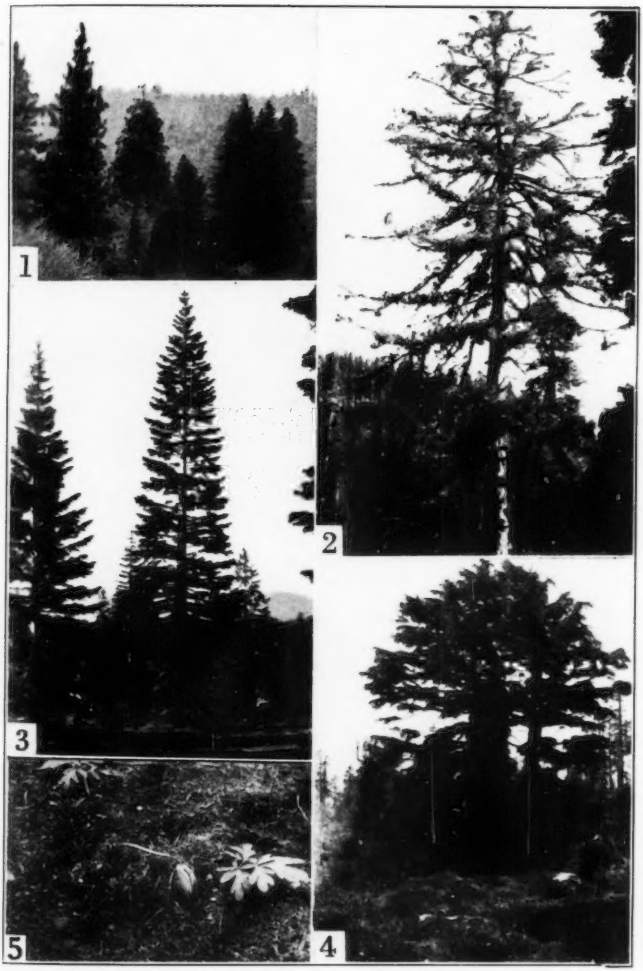

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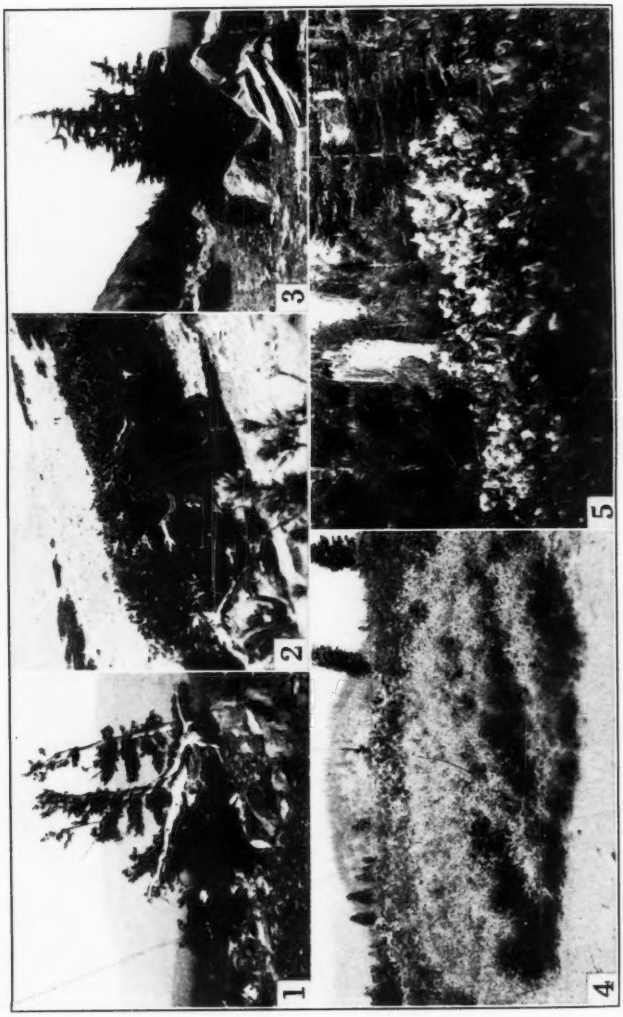

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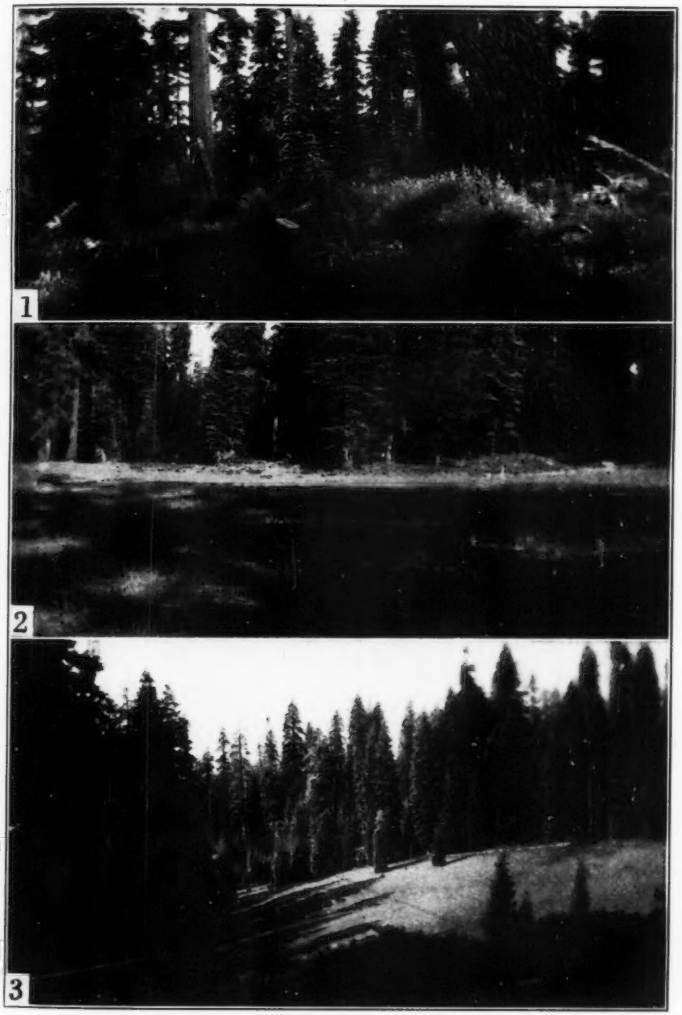

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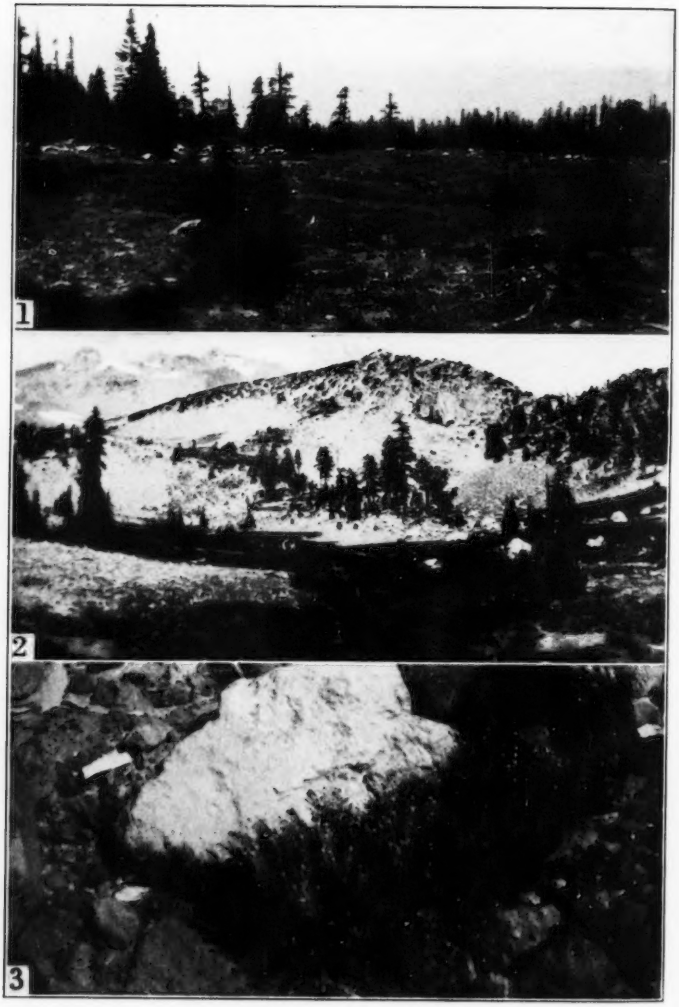

PLATE 7

PLATE 8

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The Aestival Flora of the Mesilla Valley Region, New Mexico

F. R. Fosberg

This report is the result of a study of the ecology and distribution of the plants in a section taken across the Mesilla Valley, Dona Ana County, New Mexico, in the region of the little town of Mesquite, from Afton on the west to the foot of the south end of the Organ Mountains on the east and including the small, isolated Pyramid (Bishop's Cap) Peak Range. The bases for the discussions in the paper are collections of and observations upon the plants which flowered during and after the summer rainy season and upon such perennials which, although they did not flower during this period, were identifiable and of sufficient abundance to be considered as important components of the vegetation of their particular community.

The writer was privileged to spend two months, from the middle of July to the middle of September, 1930, in this region collecting plants. This was done in connection with the Shelter Cave expedition of the Paleontology department of the Los Angeles Museum. The great diversity of conditions of altitude, substratum, drainage and exposure immediately suggested an ecological study in connection with the collection of the plants and the work was done with this in mind. The diversity of conditions mentioned above was not equaled in any other area observed in the region, and since it includes practically all the important types of vegetation represented in the region within the altitudes covered this area seems the ideal one for the work.

Apologies are offered for any inadequacies in the data or material collected and for any misinterpretations of such data here included. Furthermore, suggestion and criticisms from others will be greatly appreciated. Thanks are due Mrs. Agnes Chase, Dr. Sydney F. Blake, Dr. Phillip A. Munz, Dr. Ivan M. Johnston, Mr. I. W. Clokey, Dr. Mildred E. Mathias, Dr. C. Leo Hitchcock, Dr. Carl Epling, and Mr. E. E. Stanford for their kind assistance in the determination of difficult groups of plants, to Dr. H. L. Shantz for his encouragement and advice, and to Dr. Hildegarde Howard, Dr. F. E. Egler, and Dr. E. L. Little, Jr., for their suggestions for improvement of the manuscript.

The specimens upon which the paper is based are being incorporated into the Herbarium of the Los Angeles Museum. Duplicate sets, more or less complete, are being prepared for exchange with other institutions. The cacti are being cultivated in Hancock Park, Los Angeles, with some duplicates in the gardens of Dr. Arthur D. Houghton and Mr. Wright M. Pierce.

The account is intended only to be descriptive, to provide materials for future interpretation of the origin and relationships of the vegetation. No attempt is made to interpret the vegetation from the point of view of the

VEGETATION AND SUBSTRATUM MAP OF
MESILLA VALLEY REGION
Dry stream beds or washes.
Recent basalt flows.
Grassland (Hilaria mutica) on ancient flood plain.
Grassland (Bouteloua eriopoda) and cactus-yucca on porphyritic alluvial slope.
Pinyon-juniper on lower slopes of mountains.
Creosote bush (Larrea-Flourensia) on limestone alluvium (east side of river) and basalt flows and alluvium (west side of river).
Dacite hills.
Alluvial hills at edge of terrace.
Atriplex-Prosopis sand-dunes.
Salt-desert-shrub belt in bottom of broad ravine along river.
Scale 1/62,000
Contour interval 25 and 50 feet (datum is mean sea level)
FRANKLIN RANGE
RIO GRANDE
MESILLA VALLEY
LAS CRUCES
MESILLA
SANTA FE RAILROAD

successions involved. In this connection readers are referred to two papers by R. S. Campbell (Ecology 10:392-398, 1929; Jour. Agr. Res. 43:1027-1051, 1931), treating successions in the Jornada region, immediately to the north, for principles which may apply to certain of the types of vegetation considered below. For a detailed consideration of the geology of the region reference may now be made to an excellent and detailed paper by K. C. Dunham, published as Bull. 11, New Mexico School of Mines, 1935, subsequent to the writing of this paper, and referred to in several footnotes.

Topography and Substratum[1]

The area under discussion is a strip approximately ten miles wide across the broad valley of the Rio Grande. On the east it ends at the foot of the precipitous Organ Range. On the west it extends to Afton, a cattle loading station on the Southern Pacific. Had there been opportunity, operations would have been extended to the base of the Florida (West Potrillo) Mts. On the north and south there are no natural boundaries, and the limits of the area were established merely as a result of convenience in collecting and having a sufficient area upon which to base conclusions. The map will show its position with reference to the surrounding country. It is a copy of a map prepared by the writer with the Las Cruces sheet, U. S. Geological Survey, as a base.

Below Don Ana the Rio Grande runs through a broad level valley, evidently an ancient flood plain, which seems to be a continuation of the great Jornada del Muerte further north.[2] Through this valley the Rio Grande has cut a broad ravine to a depth of about 125 meters. This ravine is three or four miles in width and the edges of the terraces on either side are eroded down to the condition of series of low rounded gravelly hills.[3] The floor of the ravine is of a fine, silty alluvium, alkaline, and with extremely poor drainage. This, in its natural state, is rather heavily covered with vegetation. The water supply is comparatively great. Small areas of sand dunes are scattered here and there over the floor of this ravine. On the east side, at the foot of the small alluvial hills that form the edge of the terrace is a gently sloping strip of sand dunes partially bound by *Atriplex* and *Prosopis*. The hills themselves, on both sides, being of gravel are very well drained and rather barren of vegetation. They have sandy washes between them which are more heavily vegetated.

The origin of the material that makes up the broad terraces is apparently widely varied. Both wind and water have probably been transporting agencies. Its level character, its position as river terraces and the fine, silty character of its upper layers, almost an adobe, make it seem evident that it is an ancient

1 A detailed account (K. C. Dunham, The Geology of the Organ Mountains etc., Bull. 11, N. Mex. Sch. Mines, 1-272, 1935) of the geology of the region under discussion has been published subsequent to the preparation of the account given below. Readers are referred to pp. 163-183 for an elaboration, and, for the most part, confirmation, of the observations and suggestions presented in the following paragraphs.

2 Dunham, l.c. p. 178.

3 Dunham, l.c. p. 180.

flood plain, either of the present Rio Grande or of an ancient river, predecessor to the Rio Grande, which possibly ran the length of the Jornado del Muerte and across the present course of the Rio Grande toward the Florida Mountains.[4] The depressions or sinks in the lower Jornada and in the region near Afton may possibly be remnants of the course of such a stream, much disturbed by subsequent warpings and volcanic activity. The altitude of this plain is about 1300 meters. On the east terrace, just southwest of the Organ Mountains, lies the P'yramid (Bishop's Cap) Peak Range, an isolated mass of warped Magdalena limestone (Pennsylvanian) rising to about 300 meters above the surrounding plain. This is surrounded at the base by alluvial fans of limestone debris washed down from the peaks which rise above in great ledges of limestone, produced by the erosion of strata of different hardness and degree of warping. Approaching this on the east and north are fans of porphyritic alluvium from the Organ Mountains. These mountains arise almost like a vertical wall, cut by canyons into rugged domes and pinnacles.

Evidences of igneous intrusion and extrusion of several different ages are abundant in the region. West of the river are a series of cinder cones which have given rise to lava flows running toward the river. From the fresh character of the lava and scoria and the presence of small, open craters in the tops of several of the cones one cannot consider them any older than late Quaternary. W. T. Lee (Geol. Soc. Am., Bull. 18:211-220, 1907) proves that the flood plain cannot be older than Quaternary, on the basis of a number of fossils, and considers the neighboring craters, south of Afton, with flows on top of these Quaternary sand plains to be recent. It is safe to assume approximately the same age for the cones and flows under discussion.[5]

About two miles east of the river just above Vado is a little clump of hills of dacite (?) porphyry.[6] These are doubtless the remains of an intrusion into the plain before its dissection by the Rio Grande in its present course. The summit of the highest of these hills is a little lower than the level of the terraces. They are located near the lower side of the alluvial hills marking the ancient edge of the terrace. I would not venture to estimate their age. They are greatly weathered by cleavage into thin plates, probably due to changes in temperature. The organ Mountains are the results of an enormous intrusion of a red porphyry which, judging by the ruggedness cannot be of a very great age.[7]

Climate

Due to the altitude the temperature seldom reaches extreme heights. The mean monthly temperatures as given by Campbell (Ecology X:393, 1929) vary from 42° F. in December to 80° F. in July. The heavy rainy season is

4 Dunham, l.c. p. 180.

5 Dunham, l.c. p. 181-182.

6 Not discussed by Dunham, though indicated on his map.

7 Dunham, l.c. 56-89, considers the red porphyry (Soledad Rhyolite) which makes up the southwestern portion of the range to be an enormous extrusion, somewhat antecedent to the great batholithic intrusion which makes up the main mass of the mountains, and gives convincing evidence to support this view.

in the summer from July to September. This is the growing and flowering season for most of the plants of the region. Some flower after the scant spring rains, but some, even of these, have a second blooming season in the summer. The rainfall is at best very irregular, both in occurrence and distribution. Dry years are many. The rain is usually in the form of isolated showers accompanied by violent thunder and lightning. The lightning is rather important because of the damage that it does to the *Yucca* and *Dasylirion*. There are to be seen many trunks of these plants with the leaves almost completely burned off.

Plant Communities

The Merriam system of life zones would place the whole area under consideration in the Lower Sonoran zone with the exception of the foot of the Organ Mountains and the alluvial fans extending from them. The fans and some of the more exposed slopes partake of the character of both Upper and Lower Sonoran. The canyons and northerly slopes of the mountains are distinctly upper Sonoran. This is evidenced by the presence of *Quercus, Juniperus, Morus,* and *Ungnadia.*

By following the system used by Shantz in the Atlas of American Agriculture the territory in the Lower Sonoran zone may be satisfactorily divided into formations and associations.

The flat bottom of the ravine along the Rio Grande is of the salt desert shrub division of the desert shrub formation. This could be divided into several associations, but in this valley these are so hopelessly mixed up that to try to describe or map them would lead nowhere. The distinct types represented are *Sueda* (seepweed), *Allenrolfea* (pickleweed), *Distichlis* (saltgrass), *Populus-Salix* (cottonwood-willow), and *Sporobolus airodes* (tussock grass).

The remainder of the Lower Sonoran area excepting the grassland is of the southern desert shrub. The associations of this represented are the *Larrea* (creosote bush), yucca-cactus, and *Prosopis* (mesquite). The division of the *Larrea* association here is the *Larrea-Flourensia* (black brush). That of the yucca-cactus is the *Agave-Dasylirion* (lechuguilla-sotol). The *Prosopis* is represented by the *Atriplex-Prosopis* (mesquite-chamiso).

The grassland on the level prairies of the ancient flood plain is mesquite grass or desert grass of the *Hilaria mutica* (tobosa grass) type. The soil here is a heavy adobe-like silt and the drainage is very poor. The lower part of the porphyritic alluvial fan at the foot of the Organ Mountains is a grassland of the *Bouteloua eriopoda* (black grama) type. On the uppermost portions of the fan the grass is scarcely in evidence, being more and more replaced by *Yucca baccata.* This yucca together with the growth of cactus, *Dasylirion* and *Yucca macrocarpa* on the lowermost dry south and west slopes of the mountains, forms a rather poor development of the yucca-cactus association. The truly upper Sonoran vegetation on the north slopes and in the canyons is probably the extreme lower limit of the *Pinus-Juniperus* (pinyon-juniper) woodland, although there are no pinyons and not many junipers.

Southern Desert Shrub

ATRIPLEX-PROSOPIS

This community has been discussed by Campbell (Ecology 10:392-398, 1929) under the name *Prosopis* sand dunes in much more detail than could be done here. There is a belt of this type on each side of the river but they are not in corresponding positions. On the east side of the Rio Grande it lies on the small gently sloping fans at the foot of the rolling hills that form the edge of the terrace. Although the soil is sandy here, it contains some clay which keeps it from blowing as much as it otherwise might. On the west side it lies on the terrace itself between the *Larrea* belt and the grasslands. Here it is very sandy.

Other than the two dominants, *Prosopis chilensis* var. *glandulosa*, and *Atriplex canescens* only three plants were collected, *Lepidium montanum* var. *alyssoides*, *Hoffmanseggia densiflora*, and *Euphorbia serpens*. *Wislizenia refracta* was seen but not collected.

LARREA

Larrea divaricata flourishes where the drainage is good. In this region the association reaches its best development on the limestone alluvial fans around Pyramid Peak and on top of and in the vicinity of the recent lava flows on the west side of the river. Here *Larrea* grows in almost pure stands or in some places mixed with *Krameria glandulosa*, *Acacia constricta*, *Flourensia cernua*, *Gutierrezia sarothrae* and *G. lucida*. *Opuntia macrocentra* is scattered here and there. A few annuals are found after the rainy season, especially in rocky areas and along gullies and washes. Of these *Pectis papposa* is in places so abundant that it forms almost a carpet.

On the hills of coarse alluvium mixed with silt that form the edges of the terraces the *Larrea* is rather sparse and mixed with *Yucca elata*, *Yucca macrocarpa*, *Fouquieria splendens*, *Ziziphus lycioides*, *Prosopis chilensis*, *Krameria glandulosa* and *Flourensia cernua*. *Dyssodia Berlandieri*, *Psilostrophe lanata* and *Martynia althaefolia* seem to be the more important smaller plants here.

Between these low hills are broad sandy watercourses which, though dry most of the year become torrents after large storms. In these the *Larrea*, although not in a particularly heavy stand, grows to great size, sometimes being as much as four meters tall. In these washes by far the most important annual is *Lepidium montanum* var. *alyssoides*. On the east side of the river, particularly, this is extremely abundant. There is quite a surprising difference between the floras in these washes on the two sides of the river. *Rhus microphylla*, *Yucca elata*, *Senecio longiloba*, *Stephanomeria pauciflora*, *Funastrum heterophyllum*, *Euphorbia flagelliformis*, *Bouteloua aristidioides*, *Prosopis chilensis*, *Martynia althaefolia*, *Atriplex canescens*, *Boerhavia Wrightii*, and *Nama hispida* are found on both sides. On the west side there are *Dalea scoparia*, *Artemisia filipes*, *Chrysopsis Berlandieri*, *Oenothera runcinata*, *Dalea glaberrima*, and *Thelesperma gracile* which do not appear at all or at least not in any abundance on the east side. On the east side *Chilopsis linearis* var. *glutinosa* was the most characteristic plant in these washes and it was scarcely

seen at all on the west side. *Acacia constricta, Dalea formosa, Polanisia trachysperma, Croton neomexicana,* and *Heliotropium convolvulaceum* were found on the east side and not on the west. The only observed difference in the two habitats is that limestone makes up a large part of the alluvium on the east side and volcanic material a large part on the west.

The vegetation of the small group of porphyritic hills on the edge of the terrace on the east side is quite sparse. Stunted *Larrea* bushes grow clear to the top. This is definitely the dominant plant, although several of the other things present suggest a relationship with the yucca-cactus association on the limestone ledges of Pyramid Peak. There are no cacti or yucca-like plants at all, and only a few stunted ocotillos. A few plants of *Baileya multiradiata,* and *Selinocarpus chenopodioides* were growing on the talus slopes. *Cevallia sinuata* was collected in a draw. On the summit are a few bushes of *Atriplex canescens. Nicotiana trigonophylla, Stephanomeria pauciflora,* and *Chrysopsis hispida* also grow on the summit along with five grasses, *Setaria macrostachya, Tricachne californica, Aristida barbata, Muhlenbergia Porteri,* and *Bouteloua curtipendula.* All of these plants which grow on the summit are also present on Pyramid Peak with a possible exception of *Aristida barbata.* The conditions on the summit of these hills seem quite similar to those on the summit of Pyramid Peak. Considerable lime seems to result from the decomposition of this porphyry, as the broken rock in the bottoms of the draws is cemented together to form a breccia with a matrix which appears to be a limey clay.

The change from the *Larrea* association to the flat grasslands on the east side of the river, to the *Atriplex-Prosopis* belts on both sides and to the yucca-cactus area on Pyramid Peak is very gradual, but the line between the *Larrea* on the lime-stone alluvium and the *Bouteloua eripoda* grasslands on the porphyritic alluvium is sharp and clean cut. A narrow wash completely separates them in most places. *Larrea divaricata* is abundant throughout the yucca-cactus association up to the very summit of Pyramid Peak, but is scarcely a dominant anywhere on the peak.

Yucca-Cactus

The remarkable development of cacti on Pyramid Peak has been discussed in another paper (Fosberg. Bull. So. Cal. Acad. Sci. 30:67-73, 1931) and the species are enumerated later in this paper. The species of greatest importance in the association as here represented are *Opuntia phaeacantha, Opuntia Engelmanii* var. *Wootoni, Echinocactus horizonthalonius, E. Wislizeni, Echinocereus stramineus, E. neomexicanus, E. Rosei,* and *Coryphantha tuberculosa.* Taken together these form perhaps the largest component of the vegetation, especially on the lower slopes. Although this is the *Agave-Dasylirion* or lechuguilla-sotol the *Agave* is of little importance. Here and there are a few plants. These were not in bloom in the late summer. *Dasylirion Wheeleri* (sotol) grows here in great profusion. *Yucca macrocarpa* is also very important on the lower slopes. *Fouquieria splendens* (ocotillo) is so abundant as to be almost the dominant plant. *Prosopis chilensis* is rather abundant in the canyons. *Ptelea angustifolia* is abundant near the summit on the north side.

Coldenia Greggii, Janusia gracilis, Rhus choriophylla, Lippia Wrightii, Parthenium incanum, Flourensia cernua, and *Porophyllum scoparium* are the more important shrubs, with *Larrea divaricata* occupying an important place throughout. Characteristic annuals and small perennials are *Tidestromia suffrutescens, Tragia nepetifolia, Hibiscus involucellatus, Hedeoma thymoides, Nicotiana trigonophylla, Stephanomeria pauciflora, Trixis californica, Chrysopsis hispida, Thelesperma longipes,* and *Bahia absinthifolia* var. *dealbata. Maurandya antirrhiniflora* and *Phacelia congesta* (*P. rupestris* Greene) are present near the summit. *Triodia pulchella* is by far the most abundant grass, growing plentifully on the limestone ledges from the base to the summit. The other grasses collected were *Heteropogon contortus, Andropogon saccharoides, Setaria macrostachya, Tricachne californica, Panicum Hallii, Aristida glauca, Muhlenbergia Porteri, Sporobolus contractus,* and *Bouteloua curtipendula.* Of the ferns *Cheilanthes Feei* is abundant near the summit, *Cheilanthes myriophylla* in some of the deeper canyons and *Notholaena sinuata* var. *integerrima* and *Pellaea longimucronata* near the base. The *Notholaena* is one of the commoner plants on the ledges near the base.

At the base of the Orgon Mountains on the lowermost exposed slopes and on the upper parts of the fans is a rather poor development of this same association. Its most important constituents are, in order of their importance, *Yucca baccata, Opuntia phaeacantha, Fouquieria splendens, Dasylirion Wheeleri, Yucca macrocarpa, Echinocereus Fendleri, Echinocactus horizonthalonius, E. Wislizeni, Opuntia spinosior,* and *Ziziphus lycioides.* The *Yucca baccata* is only on the alluvial fan, on the upper portion of which it forms practically the whole vegetation, and it extends, although not in such abundance, well down into the grassland.

The Salt Desert Shrub Belt

The bottom of the broad ravine occupied by the Rio Grande is a fine, rich but highly alkaline silt. In the past it has evidently been subject to annual floods by means of which the Rio Grande deposited there thick layers of mud. The swift-moving waters are very heavily loaded with fine silt. Now, however, most of the water is caught and used for irrigation. This, of course, accomplishes the same thing. The fact that every foot of land that is not too alkaline has been under cultivation for a long time makes it difficult to be sure just what vegetation it may have supported at one time. The introduction of many highly adaptable weeds makes it even harder.

However, the presence of *Sporobolus airoides* growing abundantly as a weed in practically all of the cultivated territory suggests that it may have been the dominant plant before the land was placed under cultivation. Add to this the fact that there are large areas of *Sueda, Allenrolfea* and some *Distichlis* that lie untouched while it is seldom that a stand of *Sporobolus* is seen. The irrigation is very likely the factor that here, by leaching, keeps the alkali concentration down to the normal level for the growth of *Sporobolus.* This was doubtless accomplished by the floods in the past. The lack of either floods or irrigation in the uncultivated parts probably favors the *Sueda association* and accounts for the fact that the areas of this are so great. *Sueda suffrutescens*

seems able to stand considerable dryness as well as a high alkalinity. Thus there is a broad belt of it in practically a pure stand between the cultivated land and the *Atriplex-Prosopis* belt on the east side of the river. The lack of leaching by surface irrigation also probably accounts for the presence of *Allenrolfea* on roadsides and ditch banks in the cultivated areas. It is hard to be sure that this is a case of invasion, but it probably is. The chief cultivated crops of this valley are melons and cotton. The leaching process by means of which the land is kept suitable for cultivation is greatly aided by a system of deep drainage canals which carry the alkaline seepage water into the Rio Grande.

The native plants which seem to be successfully maintaining themselves in spite of cultivation are *Sporobolus airoides, Echinochloa colonum, E. crus-gallii, Kochia americana, Amaranthus Palmeri, A. retroflexus, Portulaca lanceolata, Glycyrrhiza lepidota, Sphaeralcea angustifolia* subsp. *lobata, Sida hederacea, Gaura podocarpa, Asclepias gallioides, Heliotropium curassavicum, Solanum eleagnifolium, Solanum rostratum, Haplopappus heterophyllus, Aster cichoriaceus, Psilactis asteroides, Verbesina encelioides* var. *exauriculata*, and *Flaveria trinervia*.

The introduced weeds collected are *Sorghum vulgare* Pers., *Cynodon dactylon* (L.) Pers., *Arundo donax* L., *Asparagus officinalis* L., *Rumex crispus* L., *Polygonum lapathifolium* L., *Salsola kali* L. var. *tenuifolia* Tausch., *Chenopodium glaucum* L., *Chenopodium leptophyllum* (Moq.) Nutt., *Chenopodium paganum* Reichenb., *Chenopodium album* L., *Melilotus alba* Desr., *Medicago sativa* L., *Caesalpinia gilliesii* Wall., *Tribulus terrestris* L., *Tamarix gallica* L., *Conium maculatum* L., *Pastinaca sativa* L., *Ipomoea purpurea* (L.) Lam., *Convolvulus arvenis* L., *Plantago major* L., *Sonchus asper* (L.) Hill., and *Helianthus annuus* L. A single plant of what seems to be *Portulaca oleracea* L. was found in a sandy spot on the terrace west of the river in the *Larrea* belt. This was the only weed noted outside the ravine bottom area.

Along the river itself *Populus Fremontii* is the outstanding component of the vegetation. With it are dense thickets of *Prosopis pubescens, Salix* of several species, *Pluchea sericea* and *Baccharis glutinosa*. The presence of this type of vegetation seems to be determined by the fact that the water supply is constant all the year around. It does not seem to flourish in any locality where the roots cannot reach an abundant supply of water at all times. The degree of alkalinity may play an important part also, but it was not possible to make the necessary comparative measurements to get any indication of such a relationship. *Anemopsis californica* and *Sitilias multicaulis* are herbs frequently growing in this association under the trees.

Scattered here and there over the floor of the valley are sandy areas forming in many places dunes. In certain places it is possible to cultivate this land, but usually it is rather unsatisfactory. The vegetation here seems to be related to both the *Atriplex-Prosopis* type and to the *Larrea* association as the latter is found in the sandy washes which cut the edges of the flood plain terraces. *Larrea*, however, is not present. The most abundant species found here is *Atriplex canescens*, but here and there other species such as *Dalea*

scoparia, Prosopis chilensis, Artemisia filiformis, and *Sporobolus giganteus* become quite abundant. The more noticeable and important herbs here are *Acanthochiton Wrightii, Abronia cycloptera, Pectis papposa, Dithyraea Wislizeni, Dalea glaberrima, Lepidium montanum* var. *alyssoides, Euphorbia flagelliformis, Oenothera runcinata, Boerhavia Torreyana, Othake spathulatum, Senecio Ridellii,* and *Senecio longilobus.* The vegetation of these sandy places has no direct relationship to the salt desert shrub, but because of its occurrence here this seems the best place to discuss it.

Upper Sonoran Zone

The presence of *Juniperus monosperma* seems to indicate that the vegetation of the canyons and north slopes in the foothills of the Organ Mountains belongs in the pinyon-juniper belt, but otherwise it could just as well be chaparral. The slopes have so little soil and are so dry that whichever the association is the development is so poor that it is scarcely recognizable. The canyon bottoms were not explored except at the mouths, as the Organ Mountains themselves are not included in the scope of this paper, and at the mouths of the canyons the walls were great cliffs, devoid of vegetation. In the bottoms, which were sometimes damp or even contained a little water, was a sparse growth of trees such as *Celtis reticulata Ungnadia speciosa* and shrubs such as *Lippia Wrightii, Croton fruticulosus,* and *Parthenium incanum.* Many herbaceous plants occur in these damp canyon bottoms, among the most conspicuous being *Stachys coccinea, Thelypodium linearifolium,* and *Parthenium lyratum.* In the rock crevices three ferns are found, *Notholaena Standleyi, Pellaea longimucronata,* and *Cheilanthes myriophylla,* along with the grass, *Muhlenbergia monticola.*

Peña Blanca, a long spur of the Organ Mountains lying to the North of Pyramid Park, was examined on the north slope. The south side was almost a sheer precipice. This locality is interesting geologically because it is one of the few, if not the only locality showing the character of the rock into which the porphyry of the Organ Range was intruded. It consists of beds of rock of a tuffaceous character with a westerly or northwesterly dip, intruded by sills of the porphyry of which the range is largely composed. The matrix of this volcanic breccia or tuff is of the character of kaolin and not at all calcareous. It appears to have been leached considerably until it has almost the appearance of a laterite or aluminum oxide. It, however, still contains fragments of unaltered rocks of other sorts. Wherever there is any soil on the north slope there is plenty of vegetation, but large areas are just bare rock. *Juniperus monosperma, Quercus arizonica, Ephedra viridis, Morus microphylla, Rhus microphylla, Rhus trilobata, Rhus choriophylla, Acacia constricta, Ungnadia speciosa* and *Celtis reticulata* are the most important trees and shrubs here. Grasses were abundant. *Lycurus phleoides, Aristida Orcuttiana, Muhlenbergia monticola, Bouteloua curtipendula, Bouteloua hirsuta, Eragrostis lugens,* and *Eragrostis pectinacea* were collected. *Notholaena sinuata, Notholaena Standleyi, Cheilanthes Lindheimeri* and *Pellaea longimucronata* were the ferns collected.

GRASSLANDS

The grasslands, as noted before, are of two types. On the alluvial fans at the foot of the Organ Mountains the vegetation is the *Bouteloua eriopoda* type of mesquite or desert grass. This contains many annuals and small perennials, but is dominated by *Bouteloua eriopoda*. It also has a scattering of *Yucca baccata*, especially on the upper part, and of a few other shrubs such as *Mimosa biuncifera, Condalia spathulata, Condalia lycioides, Atriplex canescens*, and *Parthenium incanum*.

On the level flood plain terraces the *Hilaria mutica* type of mesquite grass is present. *Hilaria mutica* forms almost the entire grass covering in this area, supplemented in the lower and more alkaline spots by *Scleropogon brevifolius*. The area occupied by this type of grassland is much greater on the west terrace than on the east. The list of annuals and herbaceous perennials found in the grassland is far too large to give here. It is practically the same on both sides of the river. A few of its important constituents are *Heliotropium Greggii, Lepidium montanum* var. *alyssoides, Lesquerella praecox, Talinum aurantiacum*, and *Cassia bauhinioides*. *Zinnia pumila* is common on the east side of the river. It is replaced by *Z grandiflora* on the west side. *Yucca elata* is scattered over this type of grassland on both sides of the river, giving a definite character to the landscape. On the west side it is in almost pure stand, with only a very few mesquite bushes here and there. *Gutierrezia sarothrae* (?) is the chief undershrub. On the east side the shrubs, although dominated by *Yucca elata*, are quite diverse. *Condalia lycioides* is abundant. *Lycium Berlandieri, Ephedra* sp., *Koeberlinia spinosa, Gutierrezia sarothrae* and several species that invade from the *Larrea association* are present on this side. The distance from the mountains to the river on the west side is much greater than on the east, and perhaps if it had been possible to collect nearer the mountains on the west the shrubs of the grasslands would have corresponded to those on the east side.

Annotated List of Indigenous Species Collected or Known to Occur in the Mesilla Valley Region

The specimens upon which this list is based are not cited but may be found in the herbarium of the Los Angeles Museum. Species which were not collected but which are mentioned by Wooton and Standley are indicated by the abbreviation W. & S.. The identifications are for the most part based upon Wooton and Standley's "Flora of New Mexico" published in the Contributions from the U. S. National Herbarium, Vol. 19. Certain groups have been sent to specialists for determination and in general a more conservative attitude has been adopted by the author than that adhered to in the above volume. In many cases, however, in groups more or less unfamiliar to the author, the names used do not necessarily represent his own species and genus concepts, but rather those of the manual used.

Following are the abbreviations used for the plant communities in which the plants mentioned occur:

Salt desert shrub	SS	Atriplex-Prosopis	MS
Larrea-Flourensia	LF	Hilaria mutica	HM
Agave-Dasylirion	AD	Bouteloua eriopoda	BE
		Pinus-Juniperus	PJ

In each case the communities in which the plant was collected or observed follow the name of the plant. The order adopted in the list is that used in the "Flora of New Mexico."

Weed species are listed in the chapter on the salt desert shrub belt (page 581) with authorities cited.

Notholaeana sinuata (Swartz) Kaulf.—PJ—On bare north facing rocks.
Notholaena sinuata var. *integerrima* Hook.—AD—Crevices in limestone, abundant.
Notholaena Standleyi Maxon.—PJ—Rock crevices.
Notholaena dealbata (Pursh) Kunze—W. & S.
Cheilanthes Feei Moore—AD—Abundant in higher limestone crevices.
Cheilanthes myriophylla Desv.—AD—Limestone crevices on south wall of canyons.
Cheilanthes Lindheimeri Hook—PJ—Rock Crevices, abundant.
Pellaea intermedia Mett.—W. & S.
Pellaea longimucronata Hook.—AD, PJ—Under and between rocks. (Usually referred to *P. Wrightiana.*)
Equisetum hyemale L.—W. & S.
Equisetum hyemale, var. *robustum* (A. Br.) A. A. Eat.—SS—Abundant on canal bank.
Juniperus monosperma (Engelm.) Sarg.—PJ—Stunted trees on bare rocky north slope.
Ephedra viridis Cov.—PJ—Rocky north slope.
Ephedra antisyphilitica Mey.—W. & S.
Ephedra trifurca Torr.—LF—Dry washes.
Typha angustifolia L.—SS—Canals and drainage ditches.
Typha latifolia L.—W. & S.
Potamogeton interior Rydb.—SS—In water of drainage ditches and reservoirs.
Najas guadalupensis (Spreng.) Morong—SS—Drainage ditches.
Lophotocarpus calycinus (Engelm.) J. G. Sm.—SS—Mud bottomed slough, in water.
Imperata brevifolia Vasey—SS—Wet places.
Andropogon saccharoides Swartz—AD, BE—Limestone crevices, floor of small canyon, grassy slope.
Heteropogon contortus (L.) Beauv.—AD, PJ—Between rocks.
Hilaria mutica (Buckl.) Benth.—HM—Silty flats, dominant species.
Tricachne californica (Benth.) Chase—LF, BE, AD—Porphyritic hills, grassy slope, limestone ledges.
Leptoloma cognatum (Schult.) Chase—W. & S.
Eriochloa polystachya H. B. K.—W. & S.
Paspalum distichum L.—SS—Edge of water, abundant.
Panicum obtusum H. B. K.—SS—Roadsides.
Panicum arizonicum Scribn. & Merr.—LF—Sandy wash, rare.
Panicum dichotomiflorum Michx.—W. & S.
Panicum capillare L. var. *occidentale* Rydb.—SS—Cultivated field.
Panicum hians Ell.—W. & S.
Panicum Hallii Vasey—AD—Canyon bottom, limestone.
Echinochloa colonum (L.) Link—SS—Wet roadside.
Echinochloa crus-galli (L.) Beauv.—SS—Waste ground.
Setaria lutescens (Weig.) F. T. Hubb.—SS—Canal bank.
Setaria macrostachya H. B. K.—LF, AD, SS—Porphyry hills, limestone ledges and summit of Pyramid Peak, roadside.
Cenchrus pauciflorus Benth.—SS—Roadsides.
Phalaris caroliniana Walt.—W. & S.
Lycurus phleoides H. B. K.—PJ—Between rocks.
Aristida adscensionis L.—LF, AD, PJ, HM—Porphyritic alluvial fan, silty flats, damp canyon bottom, lava flow.
Aristida Orcuttiana Vasey—PJ—Rocky n. slope.

Aristida barbata Tourn.—LF— Top of porphyry hills.
Aristida glauca (Nees) Walp.—AD—Between limestone rocks.
Aristida pansa Woot. & Standl.—W. & S.
Aristida Fendleriana Steud.—LF, HM—Alluvial hills, silty flats.
Aristida purpurea Nutt.—W. & S.
Muhlenbergia Porteri Scribn.—LF, AD, BE.—Usually in cactus patches or under bushes, abundant locally through communities cited.
Muhlenbergia racemosa (Michx.) B. S. P.—W. & S.
Muhlenbergia repens (Presl.) Hitchc.—W. & S.
Muhlenbergia monticola Buckl.—PJ—Steep rocky slopes, ledges.
Muhlenbergia Emersleyi Vasey—PJ—Rocky north slope, damp floor of canyon.
Muhlenbergia asperifolia (Nees & Mey.) Parodi—SS—Wet places.
Oryzopsis hymenioides (Roem.) & Schult.) Ricker—W. & S.
Sporobolus giganteus Nash—SS—Sandy places on valley floor.
Sporobolus contractus Hitchc.—SS, AD—Canal bank, dump from cave.
Sporobolus airoides (Torr.)—Torr., SS—Valley floor, one of the dominant plants.
Sporobolus Nealleyi Vasey—W. & S.
Sporobolus flexuosus (Thurb.) Rydb.—SS—Ditch banks.
Agrostis stolonifera L.—W. & S.
Trisetum interruptum Buckl.—W. & S.
Buchloe dactyloides (Nutt.) Engelm.—W. & S.
Leptochloa filiformis (Lam.) Beauv.—W. & S.
Leptochloa fascicularis (Lam.) Gray—W. & S.
Leptochloa dubia (H. B. K.) Nees—PJ—Damp canyon floor.
Bouteloua curtipendula (Michx.) Torr.—AD, PJ, BE, LF—Rocky places, ledges, alluvial fans; abundant.
Bouteloua aristidoides (H.B.K.) Griseb.—LF, SS—Sandy washes and sandy places on valley floor.
Bouteloue Parryi (Fourn.) Griffiths—W. & S.
Bouteloua barbata Lag.—SS, LF—Railroad embankment, lava flow, sandy wash.
Bouteloua eriopoda (Torr.) Torr.—BE—Alluvial fan, dominant species.
Bouteloua hirsuta Lag.—PJ—Rocky north slop.
Trichloris mendocina (Phil.) Kurtz—SS—Roadside.
Scleropogon brevifolius Phil.—HM—Low places in adobe flats.
Phragmites communis Trin.—W. & S.
Triodia pulchella H. B. K.—AD, BE, LF—Well distributed in rocky places and hard ground.
Triodia albescens Vasey—W. & S.
Triodia muticus (Torr.) Scribn.—W. & S.
Triodia grandiflora Vasey—W. & S.
Sphenopholis obtusata (Michx.) Scribn.—W. & S.
Eragrostis pilosa (L.) Beauv.—W. & S.
Eragrostis lugens Nees—PJ—Rocky north slopes, moist canyon bottoms.
Eragrostis pectinacea (Michaux) Nees—PJ—Around pool of water.
Bromus catharticus Vahl—W. & S.
Distichlis spicata (L.) Greene—SS—Wet places or places that have been wet, one of the dominant species.
Elymus triticoides Buckl.—W. & S.
Elymus canadensis L.—W. & S.
Cyperus inflexus Muhl.—PJ—Moist canyon bottom.
Cyperus speciosus Vahl—SS—Wet places.
Cyperus esculentus L.—SS—Wet places.
Cyperus erythrorhizos Muhl.—W. & S.
Eleocharis palustris (L.) Roem. & Schult.—W. & S.
Eleocharis montana (H.B.K.) R. & S.—SS—In water, drainage ditch.
Scirpus americanus Pers.—SS—Drainage ditches.
Scirpus acutus Muhl.—SS—Drainage ditches.
Scirpus paludosus Nels.—SS.—Drainage ditches.
Scirpus Brittonianus Piper—W. & S.

Scirpus occidentalis (S. Wats.) Chase—W. & S.
Carex Emoryi Dewey—W. & S.
Lemna minor L.—SS—Floating in drainage ditch.
Commelina crispa Woot.—PJ, AD—Between rocks.
Juncus balticus L.—SS—Muddy banks, wet places.
Yucca elata Engelm.—HM—Flat plains, dominant tree, not in flower.
Yucca baccata Torr.—AD—Dominant plant at the base of the Organ Mts. on the alluvial fans above the grassland, but absent from the cactus-yucca community on limestone.
Yucca macrocarpa (Torr.) Engelm.—AD, LF—Common on low rocky slopes at the base of the Organ Mts., at the base of Pyramid Peak and on the upper portions of the alluvial fans at the bases of both, also sparsely near the edges of the terraces.
Dasylirion Wheeleri Wats.—AD—On the limestone ledges of Pyramid Peak and on the rocky lower slopes of the Organs, one of the dominant species.
Agave lechugilla Torr.—AD—What seemed to be this plant was seen in some numbers locally on pyramid Peak, but, as it was not in flower it was not collected and the identification cannot be certain.
Agave neomexicana Woot. & Standl.—AD—This plant seemed to be sparsely scattered over Pyramid Peak, but, not being in flower, was not collected.
Zephyranthes longifolia Hemsl.—LF—Two or three plants in fruit found on a lava flow.
Anemopsis californica H. & A.—SS—Damp shady places along the Rio Grande.
Populus Fremontii Wats.—SS—Abundant here and there in the Rio Grande Valley, especially right along the river.
Salix exigua Nutt.—W. & S.
Salix Wrightii Anderss.—SS—Along the Rio Grande.
Quercus arizonica Sarg. (?)—PJ—Rocky north slope. The tree had only undeveloped fruit and could not be determined with certainty.
Celtis reticulata Torr.—PJ, LF—Dry canyons, foot of Black Mesa lava flow.
Morus microphylla Buckl.—PJ—Foot of north slope of Peña Blanca.
Phoradendron bolleanum (Seem.) Eichl.—PJ—On *Juniperus monosperma.*
Phoradendron orbiculatum Engelm.—PJ—On *Quercus arizonicus* (?).
Phoradendron macrophyllum (Engelm.) Cockerell—W. & S.
Phoradendron flavescens (Pursh) Nutt.—W. & S.
Comandra umbellata (L.) Nutt.—SS—Sandy places, with mature fruit.
Eriogonum Abertianum Torr. var. *neomexicanum* Gand.—AD, LF, HM—Limestone ledges, washes, flats, lava flows.
Eriogonum Abertianum Torr. var. *bracteatum* Fosberg—AD, LF, HM, BE, SS—Limestone ledges, grasslands, washes, sandy places on valley floor.
Eriogonum rotundifolium Benth.—LF, BE, HM, SS.—Washes, grasslands, sandy places on valley floor. Both this species and the previous one grew to immense size on the loose dirt in the dump at the mouth of Conkling Cave.
Eriogonum Wrightii Torr.—BE, PJ—Washes, rocky places.
Eriogonum annuum Nutt. —W. & S.
Eriogonum trichopodum Torr.—W. & S.
Rumex hymenosepalus Torr. W. &. S.
Rumex mexicanus Meisn.—SS—Wet places.
Polygonum Muhlenbergii (Meisn.) Wats.—W. & S.
Polygonum punctatum Ell.—W. & S.
Sueda suffrutescens Wats.—SS—One of the dominant plants.
Allenrolfea occidentalis (Wats.) Kuntze—SS—One of the dominant plants.
Eurotia lanata (Pursh) Moq.—AD, PJ—Limestone ledges, steep rocky north slopes.
Atriplex elegans (Moq.) Dietrich—SS—Roadside.
Atriplex argentea Nutt. (?)—SS—Banks of the Rio Grande.
Atriplex argentea Nutt. subsp. *expansa* (Wats.) Hall & Clem.—SS—Damp waste places.
Atriplex canescens (Pursh) Nutt.—MS, SS, LF, AD, BE—One of the dominant plants in the *Atriplex-Prosopis* association, widely distributed through the whole region excepting the *Hilaria mutica* flats and the *Pinus-Juniperus* association.
Corispermum nitidum Kit.—SS—Sandy places.

Cycloloma atriplicifolium (Spreng.) Coulter—W. & S.
Chenopodium leptophyllum (Moq.) Nutt.—SS—Roadside.
Chenopodium incanum (Wats.) Hell.—W. & S.
Chenopodium Fremontii Wats.—W. & S.
Kochia americana Wats.—SS—Roadsides, waste places, very abundant and variable.
Amaranthus Palmeri Wats.—SS—Roadside.
Amaranthus retroflexus L.—SS—Roadsides and waste places.
Amaranthus fimbriatus (Torr.) Benth. var. *denticulatus* M. & B.—LF—Sandy flats.
Acanthochiton Wrightii Torr.—LF, SS—Lava flows, sandy flats and sandy places on valley floor.
Tidestromia suffruticosa (Torr.) Standl.—AD, LF—Well drained rocky places, limestone slopes.
Tidestromia lanuginosa (Nutt.) Standl.—LF, HM, SS—Sandy places.
Froelichia campestris Small—PJ—Shade of bushes and in canyon bottoms.
Brayulinea densa (Humb. & Bonpl.) Small—PJ—Dry canyon floor.
Allionia incarnata L.—AD, BE—Limestone slopes, alluvial fans.
Allionia incarnata L. subsp. *villosa* (Standl.) Standl.—LF—Sandy washes.
Mirabilis glabra (Wats.) Standl. var. *recedens* (Weatherby) Standl.—W. & S.
Mirabilis multiflora (Torr.) Gray—SS—Roadsides.
Abronia cycloptera Gray—SS—Sandy places.
Abronia fragrans Nutt.—LF—Sandy washes between lava flows on w. side of valley.
Abronia Torreyi Standl.—W. & S.
Selinocarpus chenopodioides Gray—LF, BE—Alluvial fans and talus slopes.
Boerhavia viscosa oligadena Heimerl—W. & S.
Boerhavia Wrightii Gray—LF—Sandy washes.
Boerhavia Torreyana (Wats.) Standl.—LF, SS, HM—Sandy places, lava flows.
Boerhavia intermedia Jones—W. & S.
Mollugo cerviana (L.) Seringe—W. & S.
Sesuvium sessile Pers.—SS—Roadsides and ditch banks.
Trianthema portulacastrum L.—W. & S.
Portulaca pilosa L.—LF—Washes and flats.
Portulaca suffrutescens Engelm.—BE—Alluvial fan.
Portulaca parvula Gray—W. & S.
Portulaca lanceolata Engelm.—SS—Waste places.
Portulaca retusa Engelm.—W. & S.
Talinopsis frutescens Gray—AD—Limestone ledges.
Talinum angustissimum Engelm.—HM, BE—Grasslands.
Talinum aurantiacum Engelm.—HM, LF—Prairies, lava flows.
Talinum longipes Woot. & Standl.—W. & S.
Talinum parviflorum Nutt.—W. & S.
Ranunculus cymbalaria Pursh—SS—Muddy banks of the Rio Grande.
Anemone sphenophylla Poepp.—W. & S.
Clematis Drummondii T. & G.—W. & S.
Clematis ligusticifolia Nutt.—SS—Climbing over bushes, valley floor.
Escholtzia parvula (Gray) Cockerell—W. & S.
Corydalis montana Engelm.—W. & S.
Thelypodium linearifolium (Gray) Wats.—PJ—Shade of great rocks.
Euklisia valida (Greene) Woot. & Standl.—W. & S.
Dithyraea Wislizeni Engelm.—LF, HM, SS—Sandy places.
Dithyraea Griffithsii Woot. & Standl.—LF—Sand wash. Species of doubtful validity.
Nerisyrenia camporum (Gray) Greene—LF, HM—Sandy washes and grassy flats.
Lepidium montanum Nutt. var. *alyssoides* (Gray) Jones—LF, HM, MS—Widespread in communities cited, dominant plant in sandy washes.
Lepidium medium Greene—W. & S.
Lepidium lasiocarpum Nutt.—W. & S.
Lesquerella purpurea (Gray) Wats.—PJ—Rock ledges.
Lesquerella Gordoni (Gray) Wats.—W. & S.
Lesquerella praecox Woot. & Standl.—HM—Grassy flats.
Draba cuneifolia Nutt.—W. & S.
Draba gilgiana Woot. & Standl.—W. & S.

Rorippa calycina (Engelm.) Rydb.—W. & S.
Rorippa obtusa (Nutt.) Britt.—W. & S.
Descurainea pinnata (Walt.) Britt. subsp. *halictorum* (Cock.) Detl.—W. & S.
Descurainea pinnata (Walt.) Britt. subsp. *ochroleuca* (Woot.) Detl.—W. & S.
Polanisia trachysperma T. & G.—LF—Sandy washes.
Polanisia uniglandulosa (Cov.) DC.—LF, AD—Rocky places.
Wislizenia refracta Engelm.—SS, MS—Sandy places, often very abundant.
Fendlera rupicola Gray—PJ—Steep rocky north slopes.
Potentilla paradoxa Nutt.—W. & S.
Potentilla anserina L.—SS—Banks of the Rio Grande.
Fallugia paradoxa (Don) Endl.—LF, AD—Canyon bottoms and washes.
Calliandra humilis Benth.—AD—Ravine in alluvial fan.
Acacia constricta Benth.—LF, HM, PJ—Foot of limestone alluvial fans, rocky slopes, washes.
Prosopis pubescens Benth.—SS—Along river and canals.
Prosopis chilensis (Mol.) Stuntz var. *glandulosa* (Torr.) Standl.—SS, MS, LF, HM, AD—Widespread, one of the dominant species in the *Atriplex-Prosopis* and salt shrub belts.
Desmanthus illinoensis (Michx.) MacMill.—SS—Roadsides.
Mimosa biuncifera Benth.—BE—Alluvial fan, grassland.
Hoffmanseggia densiflora Benth.—MS, LF—Sandy places.
Hoffmanseggia Jamesii T. & G.—LF—Gravel wash. The plant has a very large root.
Cassia bauhinioides Gray—HM, LF, BE—Grasslands, washes; abundant on flats and in washes.
Krameria glandulosa Rose & Painter—LF, AD—Alluvial fans, edge of terrace; subdominant in *Larrea-Fluorensia* association. Seldom found in flower at this season.
Sophora sericea Nutt.—W. & S.
Amorpha fruticosa L.—SS—Roadsides.
Dalea formosa Torr.—AD, LF, PJ—Limestone ledges, sandy washes, rocky slopes.
Dalea pogonanthera Gray—AD—Broken limestone.
Dalea scoparia Gray—LF, SS—Sandy places on the west side of the valley.
Dalea alopecuroides Willd.—W. & S.
Dalea glaberrima Wats.—LF, SS—Sandy places.
Dalea Wrightii Gray—PJ—Rocky slopes.
Astragalus Wootoni Sheld.—W. & S.
Glycyrrhiza lepidota Nutt.—SS—Ditch banks, roadsides.
Vicia exigua Nutt.—W. & S.
Rhynchosia texana T. & G.—AD—Porphyritic alluvial fan.
Phaseolus heterophyllus Willd. var. *rotundifolius* (Gray) Piper—PJ—Rocky canyon bottom.
Strophostyles leiosperma (T. & G.) Piper—PJ—Rocky ledges.
Strophostyles helvola (L.) Britt. (?)—SS—Twining over weeds on canal banks.
Erodium texanum Gray—W. & S.
Linum aristatum Engelm.—LF—Edge of terrace, alluvial hills.
Linum vernale Wooton—W. & S.
Larrea divaricata Cav.—LF, AD—Throughout the two communities cited. Dominant. Has been called by various other names, as *Covillea tridentata*, *Larrea tridentata*, *L. mexicana*, *L. glutinosa* etc.
Kallstroemia brachystylis Vail—LF, HM—Sandy places.
Koeberlinia spinosa Zucc.—HM, LF—Flats and alluvial slopes.
Janusia gracilis Gray—AD, BE—Limestone ledges, rocky outcrops.
Ptelea angustifolia Benth.—AD—Limestone ledges near summit of Pyramid Peak.
Polygala alba Nutt.—AD—Limestone ledges.
Euphorbia exstipulata Engelm.—W. & S.
Euphorbia stictospora Engelm.—W. & S.
Euphorbia serrula Engelm.—LF, HM—Adobe flats, washes, lava flows.
Euphorbia chaetocalyx H. & S.—AD—Limestone ledges.
Euphorbia albomarginata T. & G.—W. & S.
Euphorbia serpens H. B. K.—SS, MS, HM, BE, LF—Wide spread, chiefly in sandy locations, muddy roadsides on valley floor.

Euphorbia Geyeri Engelm.—LF—Sandy flats.
Euphorbia micromera Boiss.—W. & S.
Euphorbia revoluta Engelm.—W. & S.
Phyllanthus polygonoides Nutt.—PJ—Shade of trees, canyon bottom.
Croton fruticulosus Engelm.—PJ—Canyon bottom.
Croton corymbulosus Engelm.—W. & S.
Croton neomexicanus Muell.-Arg.—LF, HM, BE—Washes and sandy flats.
Tragia nepetaefolia Cav.—AD, BE—Between rocks in ravines.
Rhus trilobata Nutt.—SS—Along the Rio Grande.
Rhus trilobata Nutt. var. *pilosissima* Engl.—SS, PJ—Along the Rio Grande and in the foot of the Organ Mts.
Rhus microphylla Engelm. ex Gray—LF, PJ—In washes and ravines and on rocky slopes.
Rhus choriophylla Woot. & Standl.—AD, PJ—Limestone debris and rocky slopes.
Ungnadia speciosa Endl.—PJ—Canyon bottoms.
Condalia lycioides (Gray) Weberb.—AD, BE—Alluvial fans, limestone slopes.
Condalia spathulata Gray—HM, LF, AD—Adobe flats, washes, head of porphyritic alluvial fan.
Hibiscus denudatus Benth. var. *involucellatus* Gray—AD, BE—Limestone ledges, porphyry outcrops and alluvium.
Abutilon crispum (L.) Sweet.—W. & S.
Abutilon parvulum Gray—BE—Bottom of ravine.
Abutilon malacum Wats.—AD—Limestone ledges.
Sphaeralcea digitata (Greene) Rydb.—AD—Limestone ledges.
Sphaeralcea digitata (Greene) Rydb. subsp. *tenuipes* (Woot. & Stand.) Kearn.—AD, BE—Limestone ledges and porphyry outcrops.
Sphaeralcea angustifolia var. (Cav.) Don var. *cuspidata* Gray—HM—Flat prairies.
Sphaeralcea angustifolia (Cav.) Don. subsp. *lobata* (Woot.) Kearn.—SS—Very abundant in relatively dry situations.
Sphaeralcea incana Torr.—PJ—Canyons and rocky slopes.
Sida hederacea (Dougl.) Torr.—SS—Roadsides.
Sida filiformis Moric.—AD—Limestone devris, ledges on summiti of Pyramid Peak.
Sida physocalyx Gray—W. & S.
Sida diffusa H. B. K.—W. & S.
Anoda lavaterioides Medic.—W. & S.
Sidanoda pentaschista (Gray) Woot. & Standl.—W. & S.
Ayenia pusilla L.—PJ—Shade of great rocks.
Fouquieria splendens Engelm.—AD, LF—Widely scattered, one of the dominant species in the cactus-yucca community.
Hybanthus verticillata (Orteg.) A. Nels.—W. & S.
Cevallia sinuata Lag.—AD, LF, BE—Ravine bottoms and washes.
Mentzelia multiflora Nutt.—LF, BE, SS—Washes, alluvial fans and sandy places.
Opuntia leptocaulis DC.—AD, LF.[8]
Opuntia spinosior (Engelm.) Toumey—AD, LF.
Opuntia arenaria Engelm.—AD, LF.
Opuntia kleiniae DC—W. & S.
Opuntia macrocentra Engelm.—LF, HM.
Opuntia dulcis Engelm.—W. & S.
Opuntia phaeacantha Engelm.—AD.
Opuntia Engelmannii Salm-Dyck—AD, LF, SS.
Opuntia Engelmannii Salm-Dyck, var. *Wootonii* (Grif.) Fosberg—AD.
Opuntia tenuispina Engelm.—W. & S.
Opuntia chihuahuaensis Rose—W. & S.
Opuntia filipendula Engelm. (?)—SS.
Echinocereus neomexicanus Standley—AD—I now consider that this species and the two following were all present, but as none of them were in flower, they were not collected, and all appeared in the field to be variants of a single species.

8 The Cactaceae have been discussed in a previous paper (Bull. Southern Calif. Acad. Sci. V. **30**(3):67, Sept.-Dec. 1931.)

Echinocereus chloranthus (Engelm.) Rumpl.—AD.
Echinocereus viridiflorus Engelm.—AD.
Echinocereus Fendleri (Engelm.) Rumpl.—AD, BE.
Echinocereus stramineus (Engelm.) Rumpl.—AD.
Echinocereus Rosei Woot. & Standl.—AD.
Echinocereus conoideus (Engelm. & Bigel.) Rumpl.—W. & S.
Peniocereus Greggii (Engelm.) Britt. & Rose—W. & S.
Echinocactus uncinnatus Gal.—AD, LF.
Echinocactus Wislizeni Engelm.—AD, LF, HM, PJ.
Echinocactus horizonthalonius Lem.—AD, LF.
Echinomastus dasyacanthus (Engelm.) Britt. & Rose—AD, LF.
Mammilaria microcarpa Engelm.—W. & S.
Mammillaria Heyderi Muhl.—AD, BE.
Coryphantha macromeris (Engelm.) Lem.—AD, LF, HM.
Coryphantha tubercula (Engelm.) Berger—AD.
Coryphantha Muhlenphordtii (Poselger) Britt. & Rose—LF.
Gaura podocarpa Woot. & Standl.—SS—Roadsides and ditch banks.
Oenothera chamaenerioides Gray—W. & S.
Oenothera albicaulis Pursh—W. & S.
Oenothera pallida Lindl.—W. & S.
Oenothera runcinata (Engelm.) Munz—LF, SS—Sandy places.
Oenothera runcinata (Engelm.) Munz var. *gypsophila* (Eastw.) Munz—LF—Sandy wash.
Oenothera Hookeri T. & G.—SS—Moist roadsides.
Oenothera primiveris Gray—W. & S.
Oenothera brachycarpa Gray var. *Wrightii* (Gray) Levl.—AD—Limestone ledges.
Garrya Wrightii Torr.—PJ—Canyon bottoms and rocky north slopes.
Spermolepis echinatus (Nutt.) Heller—W. & S.
Menodora scabra Gray—AD—Limestone slopes.
Centaurium calycosum (Buckl.) Fernald—SS—Shady banks of the Rio Grande.
Apocynum sibiricum Jacq. var. *salignum* (Greene) Woodson—SS—Canal banks.
Vincetoxicum productum (Torr.) Vail—W. & S.
Funastrum cynanchoides (Dec'ne) Schlecht.—SS—Twining over roadside bushes.
Funastrum heterophyllum (Engelm.) Standl.—LF—Twining over bushes in washes.
Asclepias macrotis Torr.—AD—Limestone ledges.
Asclepias galioides H. B. K.—SS—Moist roadsides.
Podostemma Lindheimeri (Engelm. & Gray) Green—W. & S.
Cuscuta squamata Engelm.—W. & S.
Cuscuta umbellata H. B. K.—LF—On *Portulaca pilosa, Pectis papposa, Boerhavia* etc. growing on lava flow.
Cressa truxillensis H. B. K.—W. & S.
Evolvulus linifolius L.—PJ—Rock ledges.
Ipomoea hirsutula Jacq.—W. & S.
Ipomoea desertorum House—W. & S.
Convolvulus incanus Vahl. (?)—AD—Porphyritic alluvium. In fruit, determination not certain.
Gilia filifolia Nutt.—W. & S.
Gilia longiflora (Torr.) Don—LF—Washes and alluvial fans.
Nama hispida Gray—LF, HM—Sandy and gravelly washes and flats.
Phacelia congesta Hook.—AD, PJ—Rock canyons, gullies near summit of Pyramid Peak. This is Greene's *P. rupestris.*
Phacelia crenulata Torr.—LF—Sandy washes. Nelson's *P. corrugata.*
Phacelia caerulea Greene—W. & S.
Phacelia intermedia Wooton—W. & S.
Ellisia micrantha (Torr.) Brand—W. & S.
Coldenia Greggii (Torr.) Gray—AD—Limestone ledges.
Coldenia canescens DC.—W. & S.
Eddya gossypina Woot. & Standl.—W. & S.
Heliotropium convolvulaceum (Nutt.) Gray—LF—Washes.
Heliotropium curassavicum L.—SS—Abundant throughout valley floor.

Heliotropium Greggii Torr.—HM, LF—Silty flats, washes.
Lappula texana (Scheele) Greene—W. & S.
Eremocarya micrantha (Torr.) Greene—W. & S.
Oreocarya hispidissima (Torr.) Rydb.—W. & S.
Cryptantha crassisepala (T. & G.) Greene—W. & S.
Cryptantha angustifolia (Torr.) Greene—W. & S.
Cryptantha pusilla (Gray) Greene—W. & S.
Verbena Wrightii Gray—W. & S.
Lippia Wrightii Gray—AD, LF, PJ—Limestone slopes, alluvial fans, cinder cones.
Lippia incisa (Small) Tidestrom—SS—Roadsides.
Teucrium occidentale Gray—W. & S.
Tetraclea Coulteri Gray—LF, HM—Sandy flats.
Mentha penardi (Briq.) Rydb.—W. & S.
Lycopus americanus Muhl.—SS—Shady banks of the Rio Grande.
Hedeoma thymoides Gray—AD, LF, PJ—Limestone crevices, washes, between porphyritic rocks.
Hedeoma nana (Torr.) Greene—W. & S.
Salvia Henryi Gray—AD—Limestone ledges.
Stachys coccinea Jacq.—PJ—Shady canyon bottoms.
Datura meteloides DC.—SS—Roadsides.
Datura quercifolia H. B. K.—SS—Wet roadsides.
Nicotiana trigonophylla Dunal.—AD, LF, PJ—Limestone ledges, canyons, lava flows, washes.
Petunia parviflora Juss.—W. & S.
Lycium Torreyi Gray—SS—Along river and canals, muddy and sandy places.
Lycium Berlandieri Dunal—LF, HM—Silty flats, washes.
Physalis lanceifolia Nees—W. & S.
Physalis longifolia Nutt.—SS—Damp roadsides.
Physalis Fendleri Gray—BE—Grasslands.
Physalis hederaefolia Gray—W. & S.
Physalis comata Rydb.—W. & S.
Solanum elaeagnifolium Cav.—SS, HM —Very abundant on valley floor; grassy flats.
Solanum nigrum L.—SS—Roadside. Rydberg's *S. interius*.
Solanum rostratum Dunal—SS—Waste places.
Chamaesaracha conioides (Moric.) Britton—AD, LF—Stony ravine bottoms.
Linaria canadensis (L.) Dum.-Cours. var. *texana* (Scheele) Pennell—W. & S.
Maurandya antirrhiniflora Humb. & Bonpl.—AD— Limestone ledges, porphyritic alluvium.
Maurandya Wislizeni Engelm.—SS—Twining over roadside bushes.
Castilleia lanata Gray—PJ—Under trees, foot of north slope of Peña Blanca.
Orobanche multiflora Nutt.—W. & S.
Chilopsis linearis (Cav.) Sweet var. *glutinosa* (Engelm.) Fosberg—LF—Vary abundant in washes.
Martynia althaefolia Benth.—LF, HM—Sandy places, washes. Has very large root.
Martynia parviflora Wooton—W. & S.
Plantago Purshii Roem. & Schult.—W. & S.
Galium microphyllum Gray—PJ—Canyon bottoms and rocky slopes.
Galium proliferum Gray—W. & S.
Houstonia polypremoides Gray—W. & S.
Sambucus mexicana Presl.—W. & S.
Ibervillea tenuisecta (Gray) Small—LF—Sandy washes, lava flows. Root large, turnip Shaped.
Apodanthera undulata Gray—LF, HM—Sandy flats and washes. Large fusiform roots.
Cucurbita foetidissima H. B. K.—SS—Valley floor. Very large roots.
Stephanomeria pauciflora Torr.—AD, LF, SS, PJ—Widely distributed and abundant in sandy and rocky situations.
Stephanomeria exigua Nutt.—W. & S. (*Ptiloria neomexicana* Greene W. & S.)
Rafinesquia neomexicana Gray—W. & S.
Lactuca pulchella (Pursh) DC.—W. & S.
Malocothrix Fendleri Gray—W. & S.

Sitilias multicaulis (DC.) Greene—SS—Wet places.
Calycoseris Wrightii Gray—W. & S.
Perezia nana Gray—BE—Alluvial fans.
Perezia Wrightii Gray—AD—Limestone crevices.
Trixis californica Kell.—AD, PJ—Rocky ledges.
Iva ambrosiaefolia Gray—AD, LF—Limestone ledges, alluvial fans.
Hymenoclea monogyra T. & G.—W. & S.
Xanthium commune Britton—W. & S.
Xanthium sp.—SS—Roadsides and cultivated fields, immature.
Ambrosia psilostachya DC.—W. & S.
Franseria confertiflora (DC.) Rydb.—SS—Sandy places.
Eupatorium Wrightii Gray—W. & S.
Carphochaete Bigelovii Gray—PJ—Rocky north slope.
Brickellia venosa (Woot. & Standl.) Rob.—PJ—Canyon bottoms.
Brickellia laciniata Gray—W. & S.
Brickellia baccharidea Gray—LF—Wash on west side of valley.
Grindelia aphanactis Rydb.—W. & S.
Grindelia squarrosa (Pursh) Dunal (?)—SS—Wet shady bank of Rio Grande.
Gutierrezia sphaerocephala Gray—AD, BE, HM—Limestone alluvium, porphyritic silty flats.
Gutierrezia sarothrae (Pursh) Britt. & Rusby—AD, LF, HM—Washes, flats, broken limestone, very abundant.
Gutierrezia lucida Greene—LF, BE, PJ—Alluvial fans, rocky slopes.
Gutierrezia furfuracea Greene—W. & S.
Selloa glutinosa Spreng.—PJ—Rocky ravines.
Chrysopsis senilis Woot. & Standl.—PJ—Rock ledges.
Chrysopsis Berlandieri Greene—LF—Sandy wash.
Chrysopsis villosa (Pursh) Hook.—W. & S.
Chrysopsis hispida (Hook.) Nutt.—AD, LF, PJ—Rocky slopes and ledges.
Haplopappus spinulosus (Pursh) DC.—AD, LF, SS—Sandy places, broken limestone.
Haplopappus spinulosus var. *turbinellus* (Rydb.) Blake—LF—Sandy washes.
Haplopappus gracilis (Nutt.) Gray—BE—Alluvial fans.
Haplopappus heterophyllus (Gray) Blake—SS—Roadsides, ditch banks, very abundant.
Euthamia occidentalis Nutt.—W. & S.
Solidago canadensis L. var. *gilvocanescens* Rydb.—SS—Damp, shady roadside.
Baccharis Bigelovii Gray (?)—SS—Banks of Rio Grande.
Baccharis glutinosa Pers.—SS—Damp places, very abundant along banks of Rio Grande.
Erigeron canadensis L.—SS, PJ—Valley floor, canyon bottoms.
Erigeron arenarius Greene—AD—Sandy ravine in alluvial fan.
Aster boltoniae Greene—W. & S.
Aster parvulus Blake—SS—Ditch banks, sandy places.
Aster hebecladus DC.—SS—Roadsides.
Aster exilis Ell.—SS—Canal banks.
Aster salicifolius Lam.—W. & S.
Aster hesperius Gray—W. & S.
Aster spinosus Benth.—SS—Wet places.
Aster tanacetifolius H. B. K.—SS, HM—Canal banks, silty flats.
Aster parviflorus Gray—W. & S.
Aster cichoriaceus (Greene) Blake—SS—Waste places.
Leucelene arenosa Keller—HM—Grassy flats.
Psilactis asteroides Gray—SS—Roadsides and canal banks.
Adenostephus humilis (Benth.) Gray—LF, BE—Washes, alluvial fans.
Adenostephus ramosissimus DC.—W. & S.
Townsendia Fendleri Gray—W. & S.
Pluchea sericea (Nutt.) Cov.—SS—Abundant along Rio Grande.
Gnaphalium Wrightii Gray—PJ—Shady rocky places.
Gnaphalium chilense Spreng.—SS—Ditch Banks.
Melampodium leucanthum T. & G.—LF, HM, BE—Lava flows, alluvial fans, grasslands.

Parthenium lyratum Gray—PJ—Canyon bottoms, under trees.
Parthenium incanum H. B. K.—LF, AD, BE, HM, PJ—Widespread, everywhere abundant.
Zinnia pumila Gray—HM, LF—Prairies and alluvial slopes.
Zinnia grandiflora Nutt.—HM—Replaces *Z. pumila* on the prairies west of the river.
Thelesperma gracile (Torr.) Gray—LF—Wash.
Thelesperma longipes Gray—AD—Limestone slopes and ledges.
Thelesperma megapotamicum (Spreng.) Ktzl.—LF—Gravel wash.
Bidens vulgata Greene—SS—Canal Bank.
Bidens bipinnata L.—PJ—Canyon bottoms.
Bidens anthriscoides DC.—W. & S.
Eclipta alba (L.) Hassk.—SS—Damp cultivated fields.
Rudbeckia tagetes James—W. & S.
Helianthus ciliaris DC.—SS—Wet places.
Helianthus canus (Britton) Woot. & Standl.—LF, SS—Alluvial hills, washes, sandy places.
Flourensia cernua DC.—LF, AD—Alluvial fans, limestone ledges. Codominant in the *Larrea-Flourensia* association.
Verbesina encelioides Benth. & Hook. var. *exauriculata* Rob. & Green.—LF, SS—Washes, sandy flats, damp roadsides.
Porophyllum scoparium Gray—AD—Limestone ledges and alluvium.
Pectis papposa Gray—LF, SS, HM—Alluvial fans, lava flows, washes and sandy places. Very abundant, flowering from the very first, growing much larger as the season advances.
Pectis angustifolia Torr.—W. & S.
Dyssodia papposa (Vent.) Hitchc.—W. & S.
Dyssodia acerosa DC—W. & S.
Dyssodia Thurberi Gray—W. & S.
Dyssodia Berlandieri (DC.) Blake—AD, LF, HM—Limestone slopes, silty flats, alluvial slopes.
Psilostrophe lanata (Nels.) Rydb.—LF, HM, BE—Alluvial slopes and grasslands.
Baileya multiradiata Harv. & Gray—LF, HM, SS—Washes, rocky hills, silty flats, sandy places, abundant.
Gaillardia pinnatifida Torr.—HM, BE—Grasslands.
Hymenopappus robustus Greene—HM, LF—Flats and washes.
Othake sphacelatum (Nutt.) Rydb.—LF, SS—Alluvial slopes, washes, sandy places.
Hymenothrix Wislizeni Gray—LF—Gravel wash.
Actinea odorata (DC.) Kuntze—SS—Roadside.
Chaenactis stevioides H. & A.—W. & S.
Bahia absinthifolia Benth. var. *dealbata* Gray—AD, LF, HM—Limestone ledges, alluvial fans, flats, widespread but not locally abundant.
Bahia biternata Gray—LF, BE—Washes, alluvial fans.
Helenium microcephalum DC.—SS—Shady banks of Rio Grande.
Flaveria trinervia (Spreng.) Mcbr.—SS—Waste places.
Sartwellia flaveria J. R. Johnston—W. & S.
Hymenoxys Mearnsii (Cock.) Woot. & Standl.—W. & S.
Artemisiia filifolia Torr.—LF, SS—Sandy places, washes. Abundant, especially on the sandy flats west of the river.
Artemisia frigida Willd. (?)—LF—Wash. Immature.
Artemisia albula Wooton—AD—Limestone ledges.
Senecio Riddellii T. & G.—SS—Sandy places.
Senecio multicapitatus Greemn.—W. & S.
Senecio longilobus Benth.—LF, HM, SS—Silty flats, washes, alluvial fans, sandy places.

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Studies in Penstemon VII

The Subsections Gairdneriani, Deusti, and Arenarii of the Graciles, and Miscellaneous New Species

David D. Keck

This paper deals with three small groups of species whose relationships have not hitherto been fully worked out. These are considered related subsections of the section *"Graciles,"* subgenus *Eupenstemon*. Also, this opportunity is taken to publish several recently recognized new units, mostly from sections that have been previously treated by the writer, or from groups whose revision is not immediately contemplated.

The time will be ripe for a detailed discussion of the probable phylogenetic relationships of the various subdivisions of *Penstemon* after a revision of the genus has been completed. The present groupings should be considered tentative proposals awaiting that time. The subsection *Gairdneriani* appears to be most closely related on the one hand to a group of suffrutescent species in the *Graciles* typified by *P. humilis* Nutt. The connection between *P. seorsus* (A. Nels.) Keck, of the *Gairdneriani*, and *P. cinereus* Piper, of the *"Graciles,"* is apparent. On the other hand, this subsection is related to section *Ericopsis* through subsection *Linarioides*, and this connection may call for the eventual elevation of the *Gairdneriani* to sectional rank.

The subsections *Deusti* and *Arenarii* appear to be derived lines perhaps also sprung from the *P. humilis* group or from the *Conferti*. They appear more closely related to each other than to any third group even though they diverge from each other in several particulars, and it is therefore appropriate to discuss them both in this paper.

I have studied the collections in the following herbaria in the preparation of this paper, and wish to take this opportunity to express my thanks to the curators of these institutions for the courtesies and help that they have given.

C—University of California, Berkeley.
CAS—California Academy of Sciences, San Francisco.
CI—Carnegie Institution of Washington, Stanford University, Calif.
F—Field Museum, Chicago.1
GH—Gray Herbarium, Harvard Univ.
M—Missouri Botanical Garden, St. Louis.1
NY—New York Botanical Garden.
Ph—Academy of Natural Sciences, Philadelphia.
Po—Pomona College, Claremont, Calif.1
Pul—State College of Washington, Pullman.1
RM—Rocky Mountain Herbarium, Univ. of Wyoming, Laramie.1
SU—Dudley Herbarium, Stanford University, Calif.
US—United States National Herbarium, Washington, D. C.

Dr. Francis W. Pennell, of the Academy of Natural Sciences, Philadelphia, has collaborated with me in the study of *Penstemon deustus*.

1 Material seen only of subsection *Gairdneriani*.

Subsectio **Gairdneriani,** subsect. nov.

Suffrutescent; stems few to several, erect from the woody crown, 1-3 dm tall; herbage cinereous-puberulent; leaves essentially linear, entire, the margins revolute; inflorescence glandular-pubescent; calyx-lobes linear-lanceolate to ovate-lanceolate, long acuminate; corolla glandular-pubescent without, not villous within but usually glandular, the throat scarcely if at all plicate, limb usually widely spreading; fertile stamens glabrous; anthers small, dehiscent throughout but not explanate; staminode flattened, not dilated, bearded with rather short yellow hairs; capsule glabrous.

KEY TO SPECIES

Corolla glabrous within, the limb small ..... 1. *P. seorsus*
Corolla glandular-pubescent within, the limb ample ..... 2. *P. Gairdneri*

1. **Penstemon seorsus** (A. Nels.) comb. nov.

Penstemon linarioides var. *seorsus* A. Nels., Bot. Gaz. 54:147, 1912.

Stems 2-3 dm tall; leaves narrowly linear, 2-3 cm long, 1-2 mm wide; calyx-lobes lanceolate to ovate-oblong, acute, narrowly scarious-margined, entire; corolla essentially tubular, 16-20 mm long, 4-5 mm wide, blue-purple, apparently without guide lines, glabrous within; anther-sacs oblong, cymbiform; staminode exserted, ± flattened, bearded chiefly dorsally for its entire length with fine short yellow hairs.

Known only from scattering collections made on the dry hills and plains of southwestern Idaho and southeastern Oregon, at elevations of *ca.* 1500 to 1800 meters. "Collected by Macbride at Twilight Gulch, Owyhee County, Idaho, in lava fields, June 22, 1911, no. 970."

IDAHO. Owyhee Co.: Twilight Gulch, *Macbride 970* (RM, type; isotypes C,F,GH, M,Po,Pul,SU,US).

OREGON. ? Co.: Mann Lake, *Leiberg 2407* (C,GH,US). Harney Co.: Steens Mountain, June 6, 1885, *Howell 512* (GH,F,M,Ph,Pul,UOregon,US). Jefferson Co.: Squaw-back Ridge, June 12, 1925, *Gorman* (Ph); Crooked River (labelled Jefferson Co., but more probably Crook Co.), May 30, 1925, *Montague* (Ph).

Under *P. Gairdneri* var. *oreganus,* Gray cites two collections that unfortunately are referable to different species. His entire note is as follows: "Var. oreganus. Strict: leaves (narrow) even the bracteal ones and most of the peduncles opposite.—Mountains of E. Oregon, *Cusick, Howell.*"

Gray had one sheet before him of each collector cited. The first specimen mentioned is that of Cusick's from Union County, and is the only one that matches the description as to most of the peduncles opposite. Accordingly, I accept it as the type of the variety. The second specimen cited came from Steens Mountain, and it differs from the first in that the leaves are truly opposite as are all of the peduncles, the limb of the corolla is narrow instead of wide and it is glabrous within instead of glandular-puberulent. This is referable to *P. seorsus.*

Superficially the two sheets look much alike, and only attention to details shows the justice of retaining *seorsus* apart from *Gairdneri* as a species. A

fundamental difference between the two specimens cited by Gray, borne out by all the other collections studied, is that the leaves of *P. Gairdneri* subsp. *oreganus*, which appear opposite, are not exactly opposite and their bases clasp only one-fourth the circumference of the stem in the usual fashion of all the forms of this species, whereas in *P. seorsus* they are truly paired and their bases meet half-way around the stem.

2. Penstemon Gairdneri Hook.

Penstemon Gairdneri Hook., Fl. Bor. Amer. 2:99, 1838.

Stems 1-3 dm tall; leaves linear, spatulate-rounded to acute, usually recurving, 1-3 or 4 cm long, 1-3 mm wide; calyx-lobes narrowly to broadly lanceolate, 5-8 mm long, acuminate to attenuate, herbaceous or the margin narrowly scarious below; corolla 15-20 or 25 mm long, 4-6 mm broad at throat, the throat scarcely ampliate, the limb broad and spreading; anther-sacs ovate-oblong, cymbiform, the line of contact short; staminode included or barely exserted, bearded more than half its length, principally dorsally, with medium short yellow hairs.

Key to Subspecies

Corolla lavender-purple with deep blue limb, the limb *ca.* 12—14 mm across, the lobes ± reflexed; sepals 5—8 mm long.
Leaves opposite, 2—7 cm long, 3—5 mm wide .....2a. *P. G.* subsp. *oreganus*
Leaves alternate, 1—3 or 4 cm long, 1—3 mm wide.....2b. *P. G.* subsp. *typicus*
Corolla rose-purple throughout, the limb usually 15—20 mm across, the lobes widely spreading; leaves alternate, short and narrow.....2c. *P. G.* subsp. *hians*

2a. **Penstemon Gairdneri** subsp. **oreganus** (Gray) comb. nov.

Penstemon Gairdneri var. *oreganus* Gray, Syn. Fl. 2(1):441, 1886.
P. oreganus Howell, Fl. N. W. Amer. 1:515, 1901.
P. puberulentus Rydb., Fl. Rocky Mts. 774, 1066, 1917. "Type: Long Valley, Ida., July 6, 1895, *Henderson 3169* (U.S.&N.Y.)."

Infrequent; on rocky slopes from 975 to 1585 m elevation in the Arid Transition Zone, Snake River watershed, northeastern Oregon and adjacent Idaho. "Mountains of E. Oregon, *Cusick*—."

Oregon. Blue Mts., 1872, *Nevins* (GH). Eastern Oregon, *Cusick 2183* (C,F,GH, M,Po,Pul,US). Union County, *Cusick 81* (GH, type; isotypes, C,F,NY,US). Baker Co.: Baker, June 11, 1902, *Jones* (Po).

Idaho. Long Valley, *Henderson 3169* (US, type of *P. puberulentus;* isotype NY). Valley Co.: Payette Lake, *Pennell & Constance 20770* (Ph); S. end of Payette Lake near McCall, *Constance 1953* (CI). Adams Co.: between Kramer and Bear, *Pennell 20821* (Ph); E. of Wild Horse Creek, Weiser Nat'l Forest, *Pennell 15356* (Ph). Washington Co.: 4 mi. S. of Midvale, *Christ 9313* (CI); 6 mi. W. of Midvale, *Pennell 15332* (Ph); Weiser, *Davis 113* (CI).

In subsp. *oreganus* the leaves are usually longer, broader, more tapering to the apex and erect than in the other subspecies. Perhaps also the flowers are generally paler, those from Payette Lake having been described as pale blue or lavender to white. Notwithstanding these distinctions, we are not willing to regard this as specifically distinct, for it tallies with *P. Gairdneri* in habitat and habit, qualities of the calyx, corolla and pubescence, and in the involute

margin of the leaves. In addition, the leaves of this unit are inserted with narrow base as in the other subspecies and are only approximately opposite as mentioned under *P. seorsus*.

2b. **Penstemon Gairdneri** subsp. **typicus** nom. nov.

Penstemon Gairdneri Hook., *loc. cit.*

Frequent on rocky outcroppings of the Blue Mountains of Eastern Oregon at elevations of 1100 to 1600 m. "Blue Mountains of N. W. America, where it was gathered by *Mr. Douglas*, but communicated to me by Dr. Gairdner."

Without exact station, Blue Mts., *Douglas* (Kew, type; phototypes C, CI, GH, NY, Po, SU; possible isotype, labelled "N.W. Am. Dougl. H. S. 1835," GH).

OREGON. Blue Mts., *Howell 509* (GH). Gilliam Co.: camp on Pine Creek, *Leiberg 175* (C,F,GH,M,NY,Po,RM,US, in poor flower, possibly = subsp. *hians*). Baker Co.: 10 mi. E. of Austin, *Keck & Clausen 3648* (C,CAS,CI,Copenhagen,F,GH, Kew,M,NY,Ph,Po,Pul,SU,UAriz.,US,Utah). Grant Co.: 2.5 mi. E. of Austin, *Keck & Clausen 3654* (C,CI,Ph,SU,US); summit of Lookout Mt., upper Canyon Creek, *Peck 17186* (NY); Prairie City, *Henderson 5502* (GH,M,SU); head of Otis Creek, *Cusick 1637* (C,F,GH,M,Pul,SU,US). Malheur Co.: Juniper Springs, *Leiberg 2267* (C,F,GH,NY,Po,SU,US). Harney Co.: Camp Harney, May 26, 1885, *Howell* (CI, F,Ph,US).

2c. **Penstemon Gairdneri** subsp. **hians** (Piper) comb. nov.

Penstemon Gairdneri var. *hians* Piper, Bull. Torr. Club 27: 396, 1900.

The common form of the species in central Washington, where it occurs on rocky prairies at elevations of 100 to 600 m. "Eastern Washington: *G. R. Vasey*, no. 432 in 1889 (type)."

WASHINGTON. Without additional locality, *Vasey 432* (GH, type; isotype NY). Douglas Co.: Moses Coulee, E. of Douglas, *Thompson 11482* (CI,NY,Ph,Pul,SU, limb narrow but corolla reddish); Egbert Springs, *Sandberg & Leiberg 355* (C,F,GH, NY,Ph,Po,Pul,US, in fruit). Grant Co.: Coulee City, *Thompson 6161* (CI,GH,M, Ph,SU,US). Chelan Co.: Wenatchee, *Nelson 657* (NY,RM,SU), *Whited 1084* (GH), *Whited 36* (Pul). Kittitas Co.: Virden, *Thompson 11584* (GH,NY,Ph,Pul, SU); 15 mi. N. of Ellensburg, *Keck & Clausen 3531* (C,CI,Ph,SU); Rattlesnake Hills, Ellensburg, *Thompson* 8251 (C,CI,M,NY,Ph,RM,SU). Yakima Co.: Upper Naches River, June 15, 1892, *Henderson* (Pul); Cleman Mt., *E. Nelson 1458* (RM), June 14, 1892, *Henderson* (F); between Wenas and Umtahnum Creeks, *Cotton 1155* (Pul); Tampico, *Flett 1184, 1187* (Pul,US?); Simco Mts., *Howell 344* (GH,US); Horse Heaven Hills, *Thompson 11521* (NY,SU). Klickitat Co.: Bickleton, July 4, 1927, *Gotfredson* (Po); Cleveland, *Suksdorf 413* (GH "fls. red (or purple)," Pul); Klickitat, June 3, 1883, *J. Howell* (Pul); opposite the Dalles, May 1891, *T. Howell* (C,F,M,NY,Pul,US); on high hills near the Columbia River, *T. Howell 1464* (C).

So far as I can learn, all of this material is reddish- or purplish-flowered, without the blue limb characteristic of plants in the Blue Mts. of Oregon. The distinction is obvious in the field. Consequently, I am inclined to consider it as a geographic subspecies unmixed with subsp. *typicus* in spite of the fact that there is considerable variation shown in the size of the corolla-limb. In some, the limb is scarcely larger than in the bluer-flowered Oregon material of subsp. *typicus*.

The corolla of subsp. *hians* bears dark guide lines that lead into the throat more prominently from the upper lip than from the lower. In subsp. *typicus*, guide lines were not noted.

The close connection between the two species included in this subsection cannot be doubted and it appears that they compose a rather independent group. There is a superficial resemblance between *P. Gairdneri* and *P. albidus* Nutt., of section *Aurator*, that is striking. The latter is a Great Plains species and comes only as far westward as Montana. Likewise, *P. seorsus* resembles *P. linarioides* Gray, of section *Ericopsis*, from which it differs principally by the more narrowly tubular corolla, lacking both beard and guide lines within the throat. The close connection between *P. seorsus* and *P. cinereus* Piper of the "*Graciles*" has already been mentioned. The phyllotaxy and glandular flowers of *P. Gairdneri* are thought to be derived characters. Therefore, an acceptable hypothesis would be that the *Gairdneriani* arose through a suitable meeting between species of the sections *Aurator* and *Ericopsis*, or between one of these and a suffrutescent member of the "*Graciles*."

Penstemon deustus and its Allies

Penstemon deustus Dougl. is a common subshrub of the northern part of the Great Basin where it is most commonly found on volcanic soils and in crevices of lava rock. It is not one of the more attractive Penstemons, for it has small, yellowish white flowers that are frequently sufficiently glandular to attach considerable dust to themselves. Its closest relative is *P. Tracyi*, a montane endemic of Trinity County, California, which is similar to it in habitat, habit, inflorescence, and size and shape of flowers. These two species stand quite apart by themselves and compose the subsection *Deusti* of the section "*Graciles*." A second pair of species, both very rare, is apparently of close relationship to them, *P. arenarius* and *P. albomarginatus*, herbaceous psammophytes of the southern Great Basin region. These peculiar species may also be placed in a subsection, the *Arenarii*. Their relationship seems to be closer to the *Deusti* than to any other group in the genus, and probably they terminate a line of development.

It is apparent that the closest relatives of the *Deusti*, aside from the *Arenarii*, are to be found among the *Conferti*, a large assemblage of species centering in the Pacific Northwest. Some of these are suffrutescent to a degree almost rivaling *P. deustus;* others have white or yellow flowers, and others have toothed leaves, so that it is difficult to find key characters to infallibly mark the subsectional lines. The two species of the *Deusti*, however, and even more so the two species of *Arenarii*, stand sufficiently apart from the rather homogeneous *Conferti* not only to justify, but to call for their inclusion in distinct subsections.

Key to Species

A. Stems woody at base; corolla narrowly tubular; inflorescence not leafy. Plants of rock crevices or rocky soil. Subsection *Deusti*.

B. Corolla externally glandular, often glandular-puberulent but never pilose within, white or ochroleucus, with fine violet-purple guide lines within throat on all sides; leaves linear-oblong to elliptic-lanceolate or broadly ovate.

usually sharply serrate-dentate, in subsp. *variabilis* often entire; inflorescence a thyrsus of 6—12 verticillasters; calyx 3.5—5 mm long; anthers purple-black; capsule 4—5 mm long; seed-coat thin, tight fitting....1. *P. deustus*

BB. Corolla externally glabrous, pilose within on lower lip, pink, without guide lines; leaves cuneate-oblong to orbicular, entire, or some obscurely denticulate toward apex; inflorescence a crowded thyrsus of 1—3 verticillasters; calyx 2.5—3 mm long; anthers yellowish; capsule 6—8 mm long; seed-coat thick, spongy .....2. *P. Tracyi*

AA. Stems herbaceous to ground-level; corolla tubular-campanulate, flesh-color, pilose at base of lower lip; inflorescence leafy. Plants of drifting sand. Subsection *Arenarii*.

C. Herbage glutinous; leaves serrate-dentate, not white-margined.....3. *P. arenarius*

CC. Herbage not glutinous, glabrous throughout; leaves entire, ± undulate, with a narrow but prominent white callous-like margin .....4. *P. albomarginatus*

Subsectio **Deusti,** subsect. nov.

Woody subshrubs 1-6 dm tall; herbage light green; leaves thick, coriaceous, ± serrate, rarely entire; inflorescence not obviously leafy, but lower bracts often relatively foliose; corolla narrowly tubular, glandular-puberulent or glabrous without, glandular-puberulent to glabrous or pilose within; throat narrow, obscurely 2-ridged anteriorly, its orifice open; anther-sacs widely divaricate, dehiscent throughout and at length explanate, ovate, hemispheric or somewhat broader than long, 0.4-0.5 mm long, the line of contact long; capsule ovoid, glabrous; seed coat alveolate-reticulate.

1. Penstemon deustus Dougl. ex. Lindl.

Fig. 1

Penstemon deustus Dougl. ex Lindl., Bot. Reg. 16:t. 1318, 1830.

Stems woody and much branched below, forming dense clumps, the shoots of the season erect, simple, glabrous or glandular-puberulent, the whole plant 2-6 dm tall; leaves of sterile shoots 1-5 cm long, 6-20 mm wide, narrowed to a slender short petiole, those of fertile shoots linear-lanceolate to elliptic-ovate, sessile or clasping, all acute to acuminate, usually coarsely dentate-serrate; calyx-lobes lanceolate to ovate-attenuate, the margin green or narrowly scarious but essentially entire; corolla 8-16 mm long, fragrant, the upper lobes united half way and slightly spreading, the lower lobes slightly longer and widely spreading; longer pair of stamens reaching orifice but scarcely exserted; staminode often slightly exserted, not dilated, glabrous or bearded toward apex and sparingly glandular-puberulent toward base; seeds 0.7-1.0 mm long, turgid, sharply rhombic-angled, brownish gray. Probably moth-pollinated.

Key to Subspecies

A. Corolla glandular-puberulent within.

B. Herbage and corolla prominently glandular-pubescent.....1a. *P. d.* subsp. *sudans*

BB. Herbage glabrous to sparingly glandular-puberulent, corollas externally glandular-puberulent to glandular-pubescent.

C. Leaves all opposite, the blades elliptic to lanceolate or oblanceolate, mostly acute and ± dentate-serrate; inflorescence simple; corolla 10—16 mm long, sparingly glandular-puberulent; (staminode mostly glabrous, sometimes bearded) .....1b. *P. d.* subsp. *typicus*

CC. Leaves usually ternate or irregular, sometimes opposite, the blades linear-

lanceolate to spatulate, less sharply serrate to entire, the teeth frequently confined to the apical portion; inflorescence usually branched, sometimes simple; corolla 8—11 mm long, more densely glandular-pubescent; (staminode usually bearded, sometimes glabrous).....1c. *P. d.* subsp. *variabilis*

AA. Corolla glabrous within, glabrate externally; herbage glabrate; leaves opposite, usually sharply serrate .....1d. *P. d.* subsp. *heterander*

1a. **Penstemon deustus** subsp. **sudans** (Jones) Pennell et Keck comb. nov.

Penstemon sudans Jones, Contr. West. Bot. 8:37, 1898.

P. deustus var. *arenarius* Jeps., Man. Fl. Pl. Calif. 916, 1925, in part. Not *P. arenarius* Greene.

Plant glandular-pubescent throughout; thyrsus typically with congested glomerules, sometimes much elongated (up to 18 nodes); corolla 8-12 mm long, very glandular both without and within; staminode glabrous.

Common in volcanic soils in Lassen County, California, at elevations of 1200 to 1700 m. "It grows on very hot and dry lava rocks between Amedee and Susanville, Cal., 4000 ft. alt., June 24, 1897" (*Jones*, Pomona Hb. type).

Lassen Co.: 12 mi. N. of Susanville on road to Horse Lake, *Howell 11880* (CAS, CI); 10—15 mi. W. of Amedee, 1897, *Jones* (Po, type); Susanville, *Keck 948* (C,CAS,CI,GH,Kew,M,Ph,Po,SU), *Keck & Clausen 3756* (CI,F,NY,Ph,Pul,RM, US); 4 mi. W. of Susanville, *Keck 953* (C,CI,GH,M,Ph,Po,SU); 2 mi. E. of Fredonyer Pass, *Heller 15194* (CI); Secret Valley, *Eggleston 7177* (NY,US); Willow Creek Canyon, July 7, 1894, *Stephens* (C).

Some of the collections from the Coast Ranges of southwestern Oregon (Curry, Josephine and Jackson counties) are somewhat glandular-pubescent in the herbage, particularly toward the inflorescence. In this character they approach subsp. *sudans*, but from the reduced quantity of glands they are intermediate to *typicus*. It seems probable that the origin of these Oregon collections was from *typicus* and quite independent of the Lassen County *sudans*. In the distribution map (Fig. 1) these Oregon collections are indicated with the *sudans* symbol, since detailed citation of *typicus* is not given in the text. From this the reader can see that whereas the glandular-pubescent Oregon specimens are intermixed with *typicus*, genuine *sudans* is separated from *typicus* by the Sierran divide.

1b. **Penstemon deustus** subsp. **typicus** nom. nov.

Penstemon deustus (as *deustum*) Dougl. ex Lindl., *loc. cit.* "Native of North-west America, where it was found by Mr. Douglas on scorched, rocky plains, in the interior. Our drawing was made in the Garden of the Horticultural Society in September 1829." Source of type seen by Pennell in Herb. University of Cambridge, labeled, "Junction of Lewis R. & the Columbia 1826 Douglas," and in Hooker's Herbarium at Kew labeled by Douglas: "*Penstemon serrulatum* on Lewis and Clark's River between the forks and confluence with the Columbia, and near the Junction of Spokane River." There is also a sheet in Bentham's Herbarium at Kew labeled, "Scorched rocks, Lewis & Clark's River Dougl," of which photographic copies are deposited at C,CI,SU. Evidently from the plains of eastern Washington, near the mouth of the Snake or of the Spokane River. These are clearly the subspecies now considered, differing however from the original description and illustration in showing the corolla glandular-puberulent both externally and especially internally.

P. ilicifolius Nutt. ex A. DC., Prodr. 10:593, 1846. Nomen.

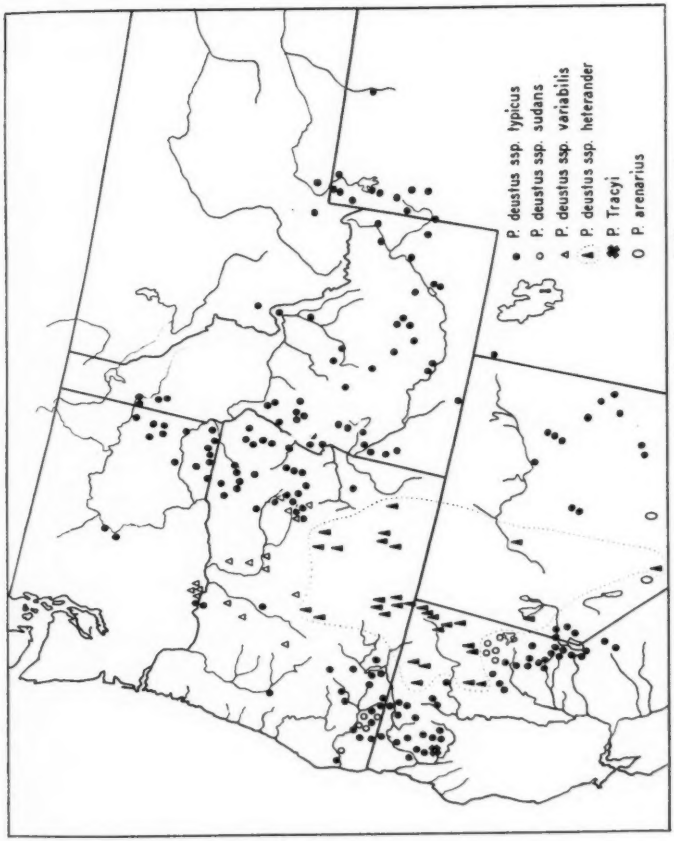

Fig. 1. Distribution of *Penstemon deustus*, *P. Tracyi*, and *P. arenarius*.

P. deustus var. *pedicellatus* Jones, Zoe 4:281, 1893. "Among junipers and piñons at about 8,000 feet altitude on gravelly slopes of mountains. July 3, 1891, at Muncy, Nevada, and also at Cherry Creek on the fourteenth of July." Type (Muncie, White Pine Co., *Jones*), Po; isotypes C,CAS,Ph,SU,US. No contrast with *deustus* was given, but the name suggests that the pedicels were supposed to be longer—a distinction that cannot be sustained. Also said to have "all the filaments antheriferous," but the only two isotypes examined had antherless and bearded staminodes. This matter is variable in *deustus*, with the antheriferous condition of the fifth filament very rare and of scattered occurrence.

P. deustus var. *suffrutescens* Henderson, Rhodora 33:206, 1931. "Dry bars of Rogue River, above Agness, Curry County [Oregon], June 30, 1929. Collected by *Mr.* and *Mrs. J. R. Leach*, their no. 2550. Type in the Herbarium of the University of Oregon." Described as differing from typical *deustus* in the more woody base, greater height, longer, more laciniate leaves, and the strongly bearded staminode, but all of these characters break, not only near the type locality of the variety, but in many parts of the range of typical *deustus*.

P. deustus var. *Savagei* Henderson, *loc. cit.* "At middle elevations, Bluffs of Grayback Mountain, Josephine County [Oregon], July 13, 1930. My no. 12828. Type in the Herbarium of the University of Oregon." Thought to differ from all other forms of the species by the presence of the "handsome and well marked stripes on the corolla," but these represent the usual condition in *typicus*. Also attention is called to the glandular pubescence on the corolla, which is present on Douglas' type specimens but was not mentioned Lindley's original description of the species.

Common from western Wyoming and southern Montana to eastern Washington, Oregon, and California, approaching the coast only through the Klamath Gap, occurring at elevations of 380-2230 m. At its most southern station, in Alpine County, California, it is found at an elevation of 2600 m. Larger and more luxuriant in mountain areas and the northern plateaus of its range, passing imperceptibly into a southern desert form, most pronounced in eastern Nevada, that tends to show narrower, less cut leaves, peduncles less than 5 cm long, corollas only 8-10 mm long, and capsules 4 mm long. Elsewhere these dimensions are usually exceeded. The extremes in eastern Nevada would appear outstanding enough to merit a name were it not for the great abundance of intermediate forms.

1c. **Penstemon deustus** subsp. **variabilis** (Suksd.) Pennell et Keck comb. nov.

Penstemon variabilis Suksd., Deutsch. Bot. Monatsschr. 18:153, 1900. "In Schluchten östlich vom Klickitatflusse, Juni 1884 und 1891." Type, *Suksdorf 999*, Pul; isotypes, GH, NY, US.

P. paniculatus Howell, Fl. N. W. Amer. 1:513, 1901. "On the high ridge between the Klickitat Valley and the Columbia river, opposite The Dalles Oregon." Type, collected by "T. Howell June, 1889," seen in Herb. University of Oregon. It differs from the type of *P. variabilis* in having a much more branched flowering stem, more nearly entire leaves, and glabrous inflorescence. The branching stem and subentire leaves mark near extremes of tendencies well developed in *variabilis*. The glabrous inflorescence is peculiar in this subspecies, but does not merit the removal of *paniculatus* from *variabilis*, since they share ternate phyllotaxy, narrow, little-toothed leaves, and glandular-pubescent corollas, and they inhabit the same local region.

Leaves ternate, quaternate, or opposite, or becoming somewhat scattered, narrowly linear to lance-oblong, 2-8 mm wide, quite entire to finely serrate toward the apex; inflorescence usually lax; sepals glandular-pubescent to rarely glabrous; corolla 10-12 (-15) mm long; staminode ± bearded apically.

Known from Klickitat County, Washington, and Gilliam, Wasco, Grant, Wheeler, Crook, and Deschutes counties, Oregon, at elevations below 1500 m. Intergrades with *typicus* are frequent in Grant County, Oregon.

1d. **Penstemon deustus** subsp. **heterander** (Torr. et Gray) Pennell et Keck comb. nov.

Penstemon heterander (as *heterandrum*) Torr. et Gray, Pacif. Rail. Rep. 2(2):123, t. 8, 1855. "Sierra Nevada California; June 30." On June 30, 1854, Lieut. E. G. Beckwith's party, for which James A. Snyder was botanical collector, was in easternmost Shasta County, traveling south from the mouth of Fall River. Type verified, *Beckwith party 57* (GH). The type is abnormal in that many of the flowers are almost regular and pentandrous, a condition of random occurrence in many sections of the genus. It was because of this peculiarity that the species was described, and later, in the Synoptical Flora, Gray submerged it under *P. deustus* with the statement, "a narrow-leaved form having the fifth filament in some flowers antheriferous." However, the entire absence of glands within the corolla marks this as the type of a distinct geographic subspecies.

Often very woody at base, stems usually meager, short, glabrous or microscopically puberulent; leaves mostly narrow and finely toothed, glabrous, glaucescent; calyx-lobes finely glandular-puberulent; corolla obscurely viscid-puberulent without, glabrous within; staminode usually glabrous, sometimes bearded, very rarely antheriferous.

As shown in the map (Fig. 1), this subspecies occupies an area in south-central Oregon, northeastern California, and northwestern Nevada to the complete exclusion of the other subspecies. It does intergrade, however, with *typicus* in eastern Oregon and Nevada. The small-flowered form of *typicus* found in eastern Nevada, mentioned under *typicus*, is often scarcely glandular within the throat of the corolla and shows an affinity for *heterander*.

OREGON. Deschutes Co.: Swamp Wells, "Crook Co.," *Leiberg 424* (C,GH,Ph,SU, US); Lava Butte, 15 mi. S. of Bend, *Hitchcock & Martin 4913* (CI). Harney Co.: French Glen, Blitzen River, *Henderson 9138* (CAS); Burns, *Peck 5904* (Ph); Silvies River, *Henderson 9151* (CAS, towards *typicus*); Sawtooth Creek, Blue Mts., *Henderson 9139* (CAS,Ph, towards *typicus*); Ten Cent Lake, E. of Steens Mts., *Henderson 9140* (CAS); Wild Horse Creek, 6 mi. S.E. of Steens Mts., *Peck 14058* (Ph,SU). Lake Co.: Poison Creek, Lake Abert, *Eggleston 7152* (US); Drake Peak, *Applegate 7832* (SU); Crane Mt., *Thompson 13198* (CI), *Applegate 7520* (SU); Paisley, *J.S.E. 2* (US); Crane Creek Mt., *Ferris & Duthie 237* (SU); Gearhart (Grayhart) Butte, *Coville & Leiberg 258* (US); Lakeview, *Constance 9926* (CI,Ph).

CALIFORNIA. Modoc Co.: Mt. Modoc, *Bruce 2206* (SU); Parker Creek, Warner Mts., *Howell 11919* (CI,CAS), *Ferris & Duthie 100* (SU); Bidwell Pass, *Applegate 8215* (SU); Mill Creek Meadows, *Applegate 8070* (SU). Siskiyou Co.: Capt. Jack's Stronghold, Lava Beds National Monument, *Applegate 7243, 9319* (SU); Red Shale Mt., E. side Medicine Lake, *Applegate 3875* (SU): Bray, *Peirson 3842* (CAS). Shasta Co.: W. Prospect Peak, August 1936, *Kramer* (CAS); 1000-Lake Basin, *Peirson 10218* (CI); Manzanita Lake, Lassen Park, July 17, 1935, *Epling & Robison* (CI). Lassen Co.: Pine Creek Flat, *Howell 12523* (CAS,SU); 5 mi. S. of Likely, *Keck & Clausen 3726* (CI,Ph); Jessen Valley, *Brenneis 12* (C).

NEVADA. Washoe Co.: Pyramid Lake, *Kennedy 1015* (C,SU,US); N. of Verdi, *Heller 10885* (C,GH,Ph,SU,US, towards *typicus*). Esmeralda Co.: Columbus Marsh, June 17, 1927, *Jones* (CAS).

2. **Penstemon Tracyi** sp. nov.

Figs. 1, 2

Basi fruticosus; caulibus glaberrimis 8-12 cm altis; foliis glaberrimis

glaucescentibus coriaceis cuneato-oblongis vel obovatis obtusis vel truncatis, inferioribus 2-4 cm longis 8-18 mm latis brevi-petiolatis integerrimis vel apice minute paucidentatis; panicula congesta pluriflora; corolla pallide rosea 11-13 mm longa tubulosa glaberrima saltem labio inferiore dense villoso; filamento sterili parce barbato; capsula 6-8 mm longa; seminibus 1.2-1.7 mm longis.

Suffrutescent subshrub; stems erect, 8-12 cm high, arising from horizontal woody branches in the rock crevices; herbage light green, glaucescent, glabrous throughout; leaves coriaceous, numerous, cuneate-oblong or oval to orbicular, the basal short-petiolate, the upper cauline usually obtuse, rarely truncate or rounded at base, usually rounded and ± apiculate at apex, mostly entire, some

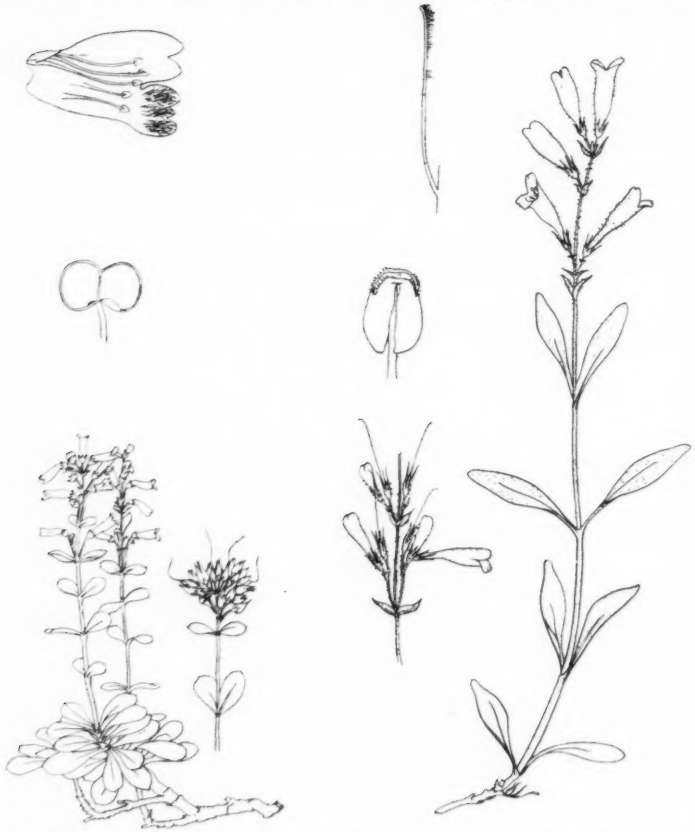

Fig. 2. Left, *Penstemon Tracyi;* habit ×1/2, anther ×8, corolla laid open ×2. Right, *P. papillatus;* habit ×1/2, anther ×8, staminode ×2.

finely denticulate especially in outer half; inflorescence a contracted dense thyrsus 2-4 cm long, of 2 or 3 approximate verticillasters; peduncles 2- to 5-flowered, appressed; calyx 2.5-3 mm long, the lobes ovate, acute, thickened, glabrous, or glandular-ciliolate along the erosulate narrowly hyaline margin; corolla pink, 11-13 mm long, tubular, not plicate within, glabrous without, densely villous within lower lip; upper lip reflexed, lower lip projecting, the lobes $^1/_3$ as long as limb; stamens included; anther-cells widely divaricate, dehiscent throughout and at length explanate, 0.4 mm long, glabrous; staminode reaching summit of throat, linear, not dilated, sparsely bearded with short hairs on outer $^1/_3$; capsule ovoid, sharply acute, 6-8 mm long; seeds 1.2-1.7 mm long, the irregularly angular spongy thick coat alveolate-reticulate, greenish or stramineous.

Type: *Joseph P. Tracy No. 14567*, taken Aug. 5, 1935, at head of White's Creek, Devil's Canyon Mts., Trinity County, California, at 2135 m (7000 ft.) elevation, Herbarium of the University of California. Isotypes SU, CI, and Joseph P. Tracy Herbarium. This is the only known collection of the species, and was taken in a remote area where the plants grew in crevices of exposed rock near the top of a ridge. Mr. Tracy reports that he found only a few plants, most of which were maturing fruit.

This very distinctive species belongs next to *P. deustus* and morphologically serves partially to bridge the gap between it and the *Conferti*. *Penstemon formosus* A. Nels., of the Blue and Wallowa Mountains, northeastern Oregon, and *P. chionophilus* Greene, of the high mountains of eastern California and adjacent Nevada, with small, roundish leaves and woody base, seem to be the members of the *Conferti* with the strongest resemblance to *Tracyi*.

Subsectio **Arenarii**, subsect. nov.

Stems herbaceous, 15-30 cm tall, arising from a somewhat woody caudex ± deeply buried in sand; herbage pallid, somewhat succulent, glabrous or nearly so; inflorescence obviously leafy; corolla tubular-campanulate, glabrous without, pilose at base of lower lip within, not glandular; anther-sacs widely divaricate, dehiscent throughout, explanate, ovate, 0.7-1.0 mm long, the line of contact short; capsule ovoid, glabrous.

3. PENSTEMON ARENARIUS Greene, Pittonia 1:282, 1889
Fig. 1

Penstemon deustus var. *arenarius* Jepson, Man. Fl. Pl. Calif. 916, 1925.

Stems several from a woody buried crown, 15-30 cm tall; herbage glabrous except for a very few scattered hairs in the inflorescence, microscopically viscid and holding much sand, particularly within the inflorescence, but no glands evident under a low power lens except on calyx, ± succulent; leaves spinulose-dentate to entire, 2-4 cm long, 5-12 mm wide; calyx-lobes lance-ovate with acuminate ± pungent tip, 6-8 mm long, the margin rather broadly scarious, pinkish, slightly erose; corolla 15-18 mm long, the throat to 6 mm wide pressed, pilose at base of lower lip, flesh-color to pale purple, with 7-9 magenta guide lines on lower lip; anther-sacs broadly ovate, explanate, purple; staminode reaching orifice, not dilated, sparingly bearded with short hairs at apex or glabrous.

Known from only three collections in south-central Nevada. "At Belleville, Esmeralda [now Mineral] Co., Nevada, W. H. Shockley (No. 348)." Type seen at University of Notre Dame; isotypes C, GH, SU. The specimen at Gray Herbarium is dated May 22, 1886, and is said to have grown in loose sand. Another collection from near Belleville is *Purpus 6449* (C, in old fruit). The third collection I have seen is from 143 miles southwest of Ely, Nevada, June 6, 1930, *E. W. Davis D-X-46* (Herb. A. O. Garrett). This location would lie about 28 miles east of Tonopah, in Nye County.

The sterile filament was described as "heavily bearded at tip," doubtless due to Greene's mistaking the beard of the lower lip for the beard on the staminode, for the flowers examined in the type collection had a glabrous staminode. Davis' collection, however, shows a moderate beard apically.

4. PENSTEMON ALBOMARGINATUS Jones, Contr. West. Bot. 12:61, 1908

Stems several from the summit of an elongated thickened fleshy deeply buried root, 15-30 cm tall; herbage pallid, glaucescent, glabrous; leaves entire, spatulate to narrowly obovate, obtuse or truncate, narrowed to a petiole-like base, only those of the inflorescence sessile and lance-oblong to broadly oval, 2.5-6 cm long, 8-22 mm wide, together with the calyx-lobes narrowly bordered with a gleaming white scarious ± scabrid margin; thyrsus 5-12 cm long, leafy, the upper bracts often finely glandular-puberulent on upper surface toward base; calyx-lobes linear-lanceolate to broadly ovate-oblong; corolla 13-18 mm long, the throat to 5 mm wide pressed, bearded with flattened yellow hairs along the two low ridges from base of lower lip, lavender-pink, whitish beneath, drying purplish at first, then brown-black, with 7-9 purple guide lines leading from lower lip into throat; anther-sacs broadly ovate, explanate, purple; staminode reaching orifice, not dilated, glabrous; seeds *ca.* 2 mm long, the irregularly winged coat alveolate-reticulate, brown.

Confined to deep sand in southern Nevada and adjacent portions of Arizona and California. "This most conspicuous and remarkable plant grows in drifting sand at Good Spring Station, Nevada, April 29, 1905. Yucca, Arizona, May 19, 1884 [Jones]."

NEVADA. Clark Co.: Good Springs, April 30, 1905, *Jones* (Po, type; isotypes C,F,Ph,SU,US); Jean, May 1915, *K. Brandegee* (C,M,NY,RM,US), May 3, 1922, *Hewett* (US).

ARIZONA. Mohave Co.: Yucca, May 17, 1884, *Jones* (Po,US), March 12, 1912, *Wooton* (US); McCracken Mine Road, beyond Yucca, *Braem 95* (CI,SU).

CALIFORNIA. San Bernardino Co.: 21 mi. E. of Newberry, *Wiegand & Upton 4278* (F); Lavic, *Munz, Johnston & Harwood 4204* (Po,RM,SU,US); Lavic Lake, *MacFadden 13315* (CI,NY); 10 mi. W. of Ludlow, May 14, 1930, *Hoffmann* (SU).

NOTES ON MISCELLANEOUS SPECIES

PENSTEMON PAPILLATUS J. T. Howell, Leafl. West. Bot. 2:119, 1938.—The drawing of this interesting new member of the section *Saccanthera*, shown in Fig. 2, was made before I learned that Mr. Howell was publishing the species. Howell had two sheets before him: the type, collected in flower at the south end of Long Valley near Hilton Creek, Mono County, California, June, 1938, by Miss Anita Noldeke (CAS), and a fruiting specimen taken

in July, 1937, by the same collector at the type locality. The present drawing, made for me by Mr. Richard Lucy, of Palo Alto, is from specimens collected near the head of Bishop Creek, on the east flank of the Sierra Nevada, in Inyo County, California, in 1935, by Robert Kessler. This specimen is in the Pomona College Herbarium, and was forwarded to me for study by Dr. Munz, who perceived its possible interest.

To Howell's excellent description I would add that the corolla is from 24-30 mm long, 5-8 mm wide at throat (to 10 mm wide pressed), the upper lip projecting, shallowly lobed, exceeded by the more deeply lobed spreading lower lip; anthers 1.5-1.9 mm long. The attenuate sepals, as shown in our figure, are the narrowest known in the section.

Penstemon papillatus does not appear to be very closely related to any other species, but may have some kinship with *P. scapoides* Keck, an endemic of Inyo County with which it shares a similar corolla, and with *P. laetus* Gray, a habitally similar species of the west side of the Sierras. Also, it has anthers of the type known previously only from the scarlet-flowered *P. Bridgesii* Gray, which is found in the region occupied by *papillatus*. The anther similarities include the combination of oblong shape, narrow cells, short line of dehiscence with very fine and short teeth along the suture. However, marked differences in corolla, leaves, calyx, and staminode between *papillatus* and *Bridgesii* must indicate that their relationship is not very close.

I am unable to concur with Howell's speculations that this species is more closely related to members of the section *Aurator* than to members of the *Saccanthera*. He infers that possibly the closest present-day connection can be traced between *P. papillatus* and *P. monoensis* Heller, of *Aurator*, but a long list of characters separates these, and aside from the shape of the calyx-lobes, which is similar between *papillatus* and certain members of *Aurator*, the characters by which Howell would link the two can all be duplicated within the *Saccanthera*, where it seems to me the relationship of *papillatus* is to be found.

Penstemon nanus sp. nov.

Pumilus, caulibus e radice suffruticoso praemorso simplicibus 3-10 cm altis cum foliis dense retrorseque cinereo-pubescentibus; foliis integerrimis linearioblanceolatis vel anguste spathulatis 20-35 mm longis 3-7 mm latis plerisque obtusis, imis petiolatis; thyrso compacto 1.5-3 cm longo ca. 2.5 cm lato glanduloso-pubescente; calyce 5-6 mm longo, lobis oblongo-linearibus abrupte acutis obtusisve pilis glandulosis et viscidis; corolla 12-16 mm longa 3.5-5 mm lata caeruleo-violacea subtus pallidiore (venis intus purpureis) superne sensim ampliata extus glanduloso-puberulente, palato plus minusve barbato, lobis rotundatis subconformibus; filamentis brevissimis; antherarum loculis ovato-oblongis moderate divergentibus vel subparallelis fere explanatis albidis; filamento sterili dilatato incluso ultra filamentis fertilibus extento sub apice hinc ad basim densissime aureo-barbato; capsula glabra.

The three following collections come from the semi-arid Great Basin region of western Utah. Millard Co.: Desert Range Experiment Station of

the U. S. Department of Agriculture, about 10 miles east of Garrison, on a dry exposure at 1675 m elevation, May 13, 1939, *Perry Plummer 7313* (Dudley Herbarium, Stanford University, type; isotypes CI, Univ. Utah); Garrison-Frisco road (doubtless between the Desert Range Experiment Station and Garrison acc. to W. P. Cottam), artemisia-pinyon belt, 1675 m elevation, May 21, 1932, *S. Hutchings 237* (Univ. Utah). Beaver Co.: Wah Wah Mountains Pass, 1980 m elevation, May 14, 1939, *Perry Plummer 7315a* (CI).

The Beaver County specimen differs from those from Millard County in having somewhat broader corollas (7 mm broad at throat when pressed) and longer stamens, the staminode reaching almost to the orifice and the fertile stamens extending to the upper half of the throat.

This new member of the section *Aurator* is most closely allied to the group including *P. Moffatii* Eastw., *P. dolius* Jones, and *P. pumilus* Nutt. Although the pubescence of its inflorescence is most like that of *Moffatii*, with all hairs gland-tipped, *P. nanus* is a decidedly smaller plant and in appearance has most in common with *pumilus*. However, it differs from all three in having white, subparallel, almost explanate (instead of purplish, widely divaricate, dehiscent throughout but not at all explanate) anther-sacs, prominently dilated and densely orange-bearded staminode, and linear-oblong but not acuminate calyx-lobes. The brevity of its stamens is likewise noteworthy.

Possibly excepting the lack of color and thin texture of the anthers, the characters found in *P. nanus* mark a new combination of previously known ones. Most of its characters can be duplicated in *P. pumilus*, a species found in central Idaho some three hundred miles to the northward. The less similar *P. dolius* occurs in the intervening region in northwestern Utah. The vesture of the staminode is of the sort found in *P. miser* Gray and *P. Grahamii* Keck, but the moderate dilation of that organ is probably traceable to some other source, such as *P. Jamesii* subsp. *ophianthus* (Penn.) Keck.

This interesting species first came to my attention when Dr. Walter P. Cottam, of the University of Utah, sent me the single specimen collected by Mr. Hutchings for determination. I am much indebted to Dr. Cottam for interesting one of his students, Mr. Plummer, in the search for additional material, which has so fortunately been productive.

Penstemon concinnus sp. nov.

Caulibus e radice suffruticoso simplicibus virgatis 5-15 cm altis ± puberulis; foliis glaberrimis vel scabrido-puberulis crassis pallidis saepe ± involutis nunc integerrimis nunc parce spinuloso-denticulatis, imis lineari-oblanceolatis vel spathulatis obtusis 2.5-5 cm longis 4-6 mm latis anguste petiolatis, caulinis sessilibus linearibus vel lineari-oblongis, floralibus gradatim in bracteas lanceolatas diminutis; thyrso dense glanduloso-pubescentibus contracto compacto vel interrupto; pedunculis erectis brevibus 2-4 floris; calyce 5-7 mm longo accrescente, segmentis lanceolatis acuminatis pilis omnibus glanduliferis; corolla 8-10 mm longa 3 mm lata vix ampliata ut videtur pallide coeruleo-purpurea palato prominenter purpureo-violaceo striato extus glanduloso-pubescente, limbo

breviter bilabiato, lobis brevibus subaequalibus recurvis, labio inferiore intus dense albo-villoso; antheris subexsertis, loculis late divaricatis fere explanatis ovatis nigrescentibus 0.6 mm longis glabris; filamento sterili exserto lineare uncinato longitudinaliter longe barbato; capsula ovata ca. 5-6 mm longa glabra.

Known only from the type collection, made by Walter P. Cottam, No. 5635 (Dudley Herbarium, Stanford University, type; isotypes CI, Univ. Utah), at Tunnel Springs, northwest corner of Desert Range Experiment Station boundary, about 10 miles east of Garrison, Millard County, Utah, at 1675 m. elevation, June 28, 1933.

This species is not closely related to any other member of the section *Aurator*. In my earlier key[1], this would fall in with *P. miser* Gray, *P. Grahami* Keck, and *P. Gormanii* Greene, and its closest approach both morphologically and geographically is with the first of these. However, the differences between *P. concinnus* and even *P. miser* are very pronounced. *P. concinnus* has the shortest corollas of any known species of the section by 2 or 3 mm; also, it has a white beard on the staminode whereas all the other species that occur west of the Rocky Mountains have yellow- or orange-bearded staminodes. It is furthermore unusual in the amount of beard developed on the lower lip, in the often entirely glabrous leaves, and in that its pale green herbage does not darken on drying.

Penstemon assurgens sp. nov.

Radicibus numerosis fibrosis; caulibus herbaceis linealiter minute puberulentibus e basi suffrutescente erectissimis virgatis tenuibus foliosis 3-4 dm altis; foliis (omnibus caulinibus) integerrimis glaberrimis viridibus, imis oblanceolatis vel anguste ellipticis acutis breviter graciliterque petiolatis, reliquis sessilibus oblongo-lanceolatis 3-8 cm longis 4-13 mm latis, superis ad basin latissimis (interdum subcordatis), floralibus abrupte in bracteas anguste lanceolatas diminutis et glandulosis; thyrso glanduloso-pubescente stricto contracto; cymis (2-5 geminis) subsessilibus 5-12-floris; calyce 4-5 mm longo, segmentis ovato-lanceolatis abrupte acuminatis vix erosis inferne scarioso-marginatis; corolla 10-13 mm longa 2.5-3 (-4) mm lata tubo parum inflato coeruleo-violacea extus glanduloso-pubescente, palato fulvo-barbato, lobis rotundatis subconformibus; antheris inclusis vel subexsertis, loculis late divaricatis 0.6-0.7mm longis partialiter dehiscentibus deorsum saccatis ± acutis; filamento sterili superne moderate fulvo-barbato.

Type, from a moist draw, three miles north of Craters-of-the-Moon, Butte County, Idaho, at *ca.* 1750 m. elevation, June 28, 1938, *Ray J. Davis 441* (Dudley Herbarium, Stanford University; isotypes C, CI). Known also from Lava Lake, Blaine County, *Davis 971* (CI), and Antelope Creek, Custer County, Davis *1242* (CI), both in central Idaho.

This species of the *Proceri* combines the matted root crown of *P. radicosus* A. Nels. and *P. Watsonii* Gray with the upper parts of a form like

1 Studies in Penstemon VI. The Section Aurator. Bull. Torr. Club **65**:236. 1938.

P. pseudoprocerus Rydb., except that the flowers are too small for that species, the leaves are too attenuate, and the stems are too slender. I judge it may be close to *P. militaris* Greene, a species from the Soldier Mountains, Idaho, unfamiliar to me, but described as having flowers 8 lines long, whereas those of *assurgens* are barely 6 lines long.

PENSTEMON WATSONII Gray, Syn. Fl. 2(1):267, 1878. *P. Fremontii* var. *Parryi* Gray ex Wats., Bot. King's Expl. 218, 1871. *P. phlogifolius* Greene, Leaflets 1:164, 1906.—Genuine forms of this species are found from western Colorado (the type locality), across much of Utah to northern Arizona, central Nevada, and southern Owyhee County, Idaho. The stems are tufted from the base like *P. assurgens* described above, and similarly the ovate-lanceolate to lance-elliptic leaves are regularly spaced along the strict stems, but the glandless inflorescence is marked by the very small calyx 2-3.5 mm long. The plant grows on dry, rocky hillsides in association with sagebrush and often with oak or juniper, at elevations of 1700 to 3000 m. There is some variation in the size of the corolla, which varies from 12-17 mm in length and from narrowly tubular to rather ampliate (3-6 mm wide pressed), but on the whole it is very uniform throughout its range. In southern Idaho a form has become geographically isolated from the main body of the species. This has enabled it to differentiate a more congested inflorescence, with the few verticillasters clustered at the apex of the stem and the flowers ascending, so that they appear imbricated when pressed. This is the form found from Blaine County to Boise County, and it has received a specific name. However, its habitat, habit, foliage, calyx, corolla, staminode, and anthers are typical of *Watsonii*, and I believe only the characters mentioned above serve to distinguish it from that. As these characters do not appear to be of specific value. I propose to call the unit a subspecies as follows:

Penstemon Watsonii subsp. **laxus** (A. Nels.) comb. nov.

P. laxus A. Nels., Bot. Gaz. 54:147, 1912. The type is *Nelson & Macbride 1196*, from Ketchum, Blaine Co., but not all of the specimens distributed under this number are members of this species. A tall form with glandular inflorescence, perhaps referable to *P. attenuatus* Dougl., has been mixed with it. I have before me specimens of subsp. *laxus* from the following additional localities: Galena Summit, Blaine Co., *Tucker 526* (CI); Castle Rock, Elmore Co., *Macbride & Payson 2865* (SU); 5 mi. E. of Atlanta, Elmore Co., *Christ & Ward 8243* (CI); Atlanta, *Christ & Ward 8338* (CI); Placerville, Boise Co., *Tucker 147-37* (Southern Branch Univ. Idaho).

PENSTEMON SPECIOSUS Dougl. ex. Lindl., Bot. Reg. 15:t. 1270, 1829.—Although the subsection *Glabri* has developed a large number of distinct species in the Rocky Mountains, almost its sole representative in the Pacific Coast states is *P. speciosus*. This species is widespread in the area, however, occurring almost entirely to the east of the crest of the Cascade-Sierran axis from central Washington to the mountains of southern California. With so broad a range it is not surprising that the species displays some diversity, but

its distribution is so nearly continuous that very few noteworthy subspecific trends can be pointed out. Characters of the corolla, anthers, habit, and even texture remain remarkably constant, although very much shortened stems are found in high montane races. The characters that are most inclined to vary are those of the shape and size of the calyx-lobes, pubescence, and bearding of the staminode, although the corolla may vary considerably in size. The calyx-lobes sometimes mark key differences between geographic subspecies, as shown in the key below, but at other times are variable within subspecies. Pubescence of the herbage is the least dependable character. Apparently through a large part of the range of the species forms occur side by side that are wholly glabrous, puberulent only on the stem, or puberulent throughout. The presence or absence of beard upon the staminode is scarcely more dependable. It comes and goes at random, and the quality and color of the beard are subject to variation. However, the beard, when present, is seldom copious or distributed far from the tip of the staminode.

The shape of the anthers is a significantly constant feature. In the Rocky Mountains the shape of the anthers frequently differs from species to species, and no species has the characteristic, slightly sigmoid curved, elongated sacs of *speciosus* excepting *P. cyaneus* Pennell. The latter has pubescent anthers and very broad calyx-lobes, but *P. speciosus* subsp. *lemhiensis*, from Lemhi County, Idaho, described below, helps bridge the gap between the two species. New explorations in central Idaho are making the geographic gaps between them, which at first seemed impressive, less significant, and perhaps eventually *P. cyaneus* will be considered no more than a subspecies of *speciosus*.

The first two collections known of *P. speciosus* subsp. *lemhiensis* were marked by having pubescent anthers (after the manner of *P. cyaneus*) and long-caudate calyx-lobes. These characters, together with a geographic separation from the more western *speciosus*, seemed to mark *lemhiensis* as a distinct species. Now, however, a third collection has been made in Lemhi County, which differs from the two previous ones only in having glabrous anthers entirely typical of *speciosus*. This discovery leaves *lemhiensis* to stand only on the geographic segregation (it occurs some 200 km to the eastward of typical *speciosus*) and the caudate calyx-lobes, with the anthers either bearded or glabrous. Particularly because the calyx-lobes are notably variable in *speciosus*, the gap is narrowed to merely a subspecific one. Although typical *P. cyaneus* has now been found in Lemhi County, its calyx-lobes are very distinct from those of *P. speciosus* subsp. *lemhiensis*. Admittedly, however, other differences between the two are minor. Possibly subsp. *lemhiensis* arose through a meeting of *cyaneus* and *speciosus*, followed by segregation and isolation.

Pubescence on the anther is an important key character in other parts of the *Glabri*, but a further instance of its fallibility in *P. speciosus* is shown in the southernmost forms from Nevada, in southern Esmeralda County. Some of these have anthers that are hispidulous near the sinus. About Lida (two localities) this character is accompanied by a prominently golden-bearded staminode. However, just a few miles to the south, on the summit of Gold Mountain, the heavy beard persists on the staminode, but the anthers are

again glabrous. In the White Mountains, not far to the north of Lida, the material is typical of the species in both respects. Here, then, is a tendency toward subspeciation, but there has been insufficient isolation as yet to make the extreme form worthy of a name.

There is one other species within the range of *P. speciosus* with which it might be confused because of the similar corolla and anthers, namely, *P. Pennellianus* Keck, described as new below. There is further discussion of this resemblance under the latter species.

A trend toward reduction in size, both of the plant as a whole and of the flower, is rather notable in the extreme form, found in Oregon, which has been named as a species by Piper, *P. deserticola*. This proposal was based upon specimens from the plains of Lake County, but I find the type inseparable from plants of higher elevations from Paulina Buttes to Crater Lake. All of these dwarfish smaller-flowered forms occur in the midst of an area in which typical forms of the species predominate, and the intergradation appears to be complete.

KEY TO SUBSPECIES OF PENSTEMON SPECIOSUS

A. Anther-sacs pubescent on the backs and sides or glabrous, the suture denticulate; flowering calyces 7—11 mm high, the lobes broadly lanceolate to ovate with slender caudate tip equaling the basal portion; Lemhi County, Idaho.....1a. *P. s.* subsp. *lemhiensis*

AA. Anther-sacs glabrous (rarely hispidulous in Esmeralda County, Nevada), the suture denticulate; calyx-lobes various, but the tip, if caudate, shorter than the broad basal portion.

B. Flowering calyces 4—6 (—8) mm high, the lobes narrowly ovate to broadly oblong or suborbicular with short tip; stems (1.5—) 3—8 dm tall; Washington to Nevada and California, mostly below 1850 m....1b. *P. s.* subsp. *typicus*

BB. Flowering calyces 8—12 mm high, the lobes lance-attenuate or ovate with acuminate tip; stems 0.5—4 dm tall; eastern California and adjacent Nevada, mostly above 1850 m.....1c. *P. s.* subsp. *Kennedyi*

1a. **Penstemon speciosus** subsp. **lemhiensis** subsp. nov.

Caulibus 4-8 dm altis glaberrimis vel minute puberulentibus; calyce 7-11 mm longo, segmentis late lanceolatis vel ovatis caudatis obscure glandulosoatomiferis; corolla 28-34 mm longa glaberrima; antheris brevi-pubescentibus vel glabris; filamento sterili nudo vix dilatato.

Granite Mountain, Lemhi County, Idaho, July 1, 1937, *Ray F. Blair s. n.* (Dudley Herbarium, Stanford University, type; isotypes, C, CI); along roadside near North Fork of Salmon River, Lemhi County, at 1370 m. elevation, June 26, 1936, *Blair* (CI); Ulysses Mt. Spring, Lemhi County, 2135 m. elevation, July 23, 1938, *Blair* (CI, the only collection with glabrous anthers).

1b. **Penstemon speciosus** subsp. **typicus** nom. nov.

Penstemon speciosus Dougl. ex Lindl., loc. cit. "Native of the banks of the Spokane River, in North-west America,"—Douglas. The type in Lindley's herbarium has not been seen, but a possible isotype in Hooker's herbarium at Kew has been studied. This is labeled: "Pentstemon speciosum. On the high sandy banks of the Columbia near Oakanagan, also on Spokan River." It is glabrous throughout.

P. glaber var. *occidentalis* Gray, Proc. Amer. Acad. 6:60, 1862. Based upon *P. speciosus* Dougl.

P. pilifer (as *piliferus*) Heller, Muhlenbergia 2:136, 1906. "The type is [Heller] no. 7991, collected June 8, 1905, on hills west of Yreka, Siskiyou county, California, growing on the banks of a small stream." The usual form.
P. rex Nels. et Macbr., Bot. Gaz. 55:381, 1913. "The following.... is named as the type: [Nelson & Macbride] no. 1999, Jarbidge, Nevada, July 9, 1912." Jarbidge is in northern Elko County. The type has finely puberulent stems.
P. deserticola Piper, Proc. Biol. Soc. Wash. 32:43, 1919. "Near Desert Well between Button Springs and Silver Lake, Lake County, Oregon, alt. 1400 m, July 5, 1894, *J. B. Leiberg* no. 402. Type in U. S. National Herbarium, sheet no. 404811. Nearest *P. speciosus* Dougl., from which it differs by the smaller corolla, differently shaped leaves, and much smaller size." This form is discussed in text above.
P. speciosus var. *pilifer* (as *piliferus*) Munz et Johnst., Bull. So. Calif. Acad. Sci. 23:35, 1924.
P. glaber and var. *utahensis* of Jepson's Manual, 913-4, 1925.

Common on rather dry plains and hillsides from north-central and eastern Washington, east of the Cascades at elevations below 1000 m., southward across southwestern Idaho to Elko and Esmeralda counties, Nevada, at elevations up to 2500 m., and through Oregon to southern California, ascending the Cascade Range only in southern Oregon and California (to 2400 m.); in California common east of the Cascade-Sierran crest southward to Nevada County and occasional to the head of Death Valley; also in the mountains from Tulare County southward around the western borders of the Mohave Desert, usually below 1900 m. At higher elevations in the central Sierra Nevada, it is largely replaced by the following subspecies.

1c. **Penstemon speciosus** subsp. **Kennedyi** (A. Nels.) comb. nov.

Penstemon Kingii var. *glauca* Kellogg, Proc. Calif. Acad. 5:39, 1873. "Found near the summit of Sierra Nevada Mts., July 10th, 1870." Collected by Kellogg near Donner Pass, Nevada-Placer county line, California. Doubt exists as to whether this variety is best assigned to the present subspecies or to *typicus*.
P. Kennedyi A. Nels., Proc. Biol. Soc. Wash. 17:97, 1904.

Herbage glabrous to pruinose-puberulent, sometimes glaucescent; stems often shorter, less strictly erect and from a woodier caudex than subsp. *typicus;* calyx-lobes typically tapering from near base to apex, sometimes elliptic or oblong-obovate with acuminate or attenuate tip; corolla of maximum size for the species, that of high montane forms often with more slender tube and throat and somewhat contracted at orifice; anthers glabrous except for the fine teeth along the suture; staminode glabrous or sparingly bearded at tip.

In Nevada from southern Eureka, Lander and Washoe counties to Nye County and the White Mountains of Esmeralda County; in California from Sierra County southward along the east flank of the Sierra Nevada to Inyo County and the White Mountains; also occasional in the Warner Mountains of Modoc County and adjacent Lake County, Oregon; found at elevations from 1700 to 3650 m. Mixing with subsp. *typicus* especially in the Warner Mountains and the Lake Tahoe region. "The excellent specimens that are taken as the type (No. 736) were collected by Prof. Kennedy at Truckee Pass, Virginia Mts., Washoe Co., Nevada, June 6, 1903." The type has been studied at Rocky Mountain Herbarium.

Penstemon Pennellianus sp. nov.

Caulibus e caudice suffrutescente erectis validis strictis 2-5 dm altis glaberrimis; foliis glabris viridibus integerrimis, radicalibus lanceolatis vel anguste ellipticis 8-25 cm longis 10-35 mm latis in petiolum elongatum angustatis, caulinis oblongo-lanceolatis usque ad ovatis acutis cordato-amplexicaulibus, floralibus inconspicuis; thyrso continuo glaberrimo (cymis 3-10 geminis multifloris) 5-25 cm longo 5-6.5 cm lato; calyce 5-10 mm longo, segmentis ovato-lanceolatis acuminatis vel subulatis vel caudatis margine membranaceis subintegris vel moderate erosis; corolla P. speciosi 26-32 mm longa 9-10 mm lata coerulea glabra; antheris inclusis plus minusve hirtellis, loculis P. speciosi 2-2.4 mm longis, staminodio filiformi vel subdilatato superne breviter hirsuto.

Known from a rather limited area in the northern end of the Blue Mountains and adjacent canyons, from Asotin County to Columbia County, Washington, and in adjacent Wallowa County, Oregon, on exposed rocky or sandy slopes and ridges at elevations of 1300 to 1800 m.

WASHINGTON. Asotin Co.: Big Butte, 10 miles southeast of Anatone, Snake River Canyon, *Downen 110* (CI). Garfield Co.: Clearwater Ranger Station, *Constance & Clements 1745* (CI). Columbia Co.: Blue Mts., June 11, 1897, *Horner* (GH); brow of high dry peak, Wolf Fork of Touchet River, *St. John, Davison & Scheibe 6966* (SU); Godman Springs, *Constance et al 1165* (CI); Wildcat Spring, *St. John & Smith 8317* (CI).

OREGON. Wallowa Co.: Joseph Creek Canyon below Flora, and 40 miles north of Enterprise, June 20, 1932, *R. Sprague* (Dudley Herbarium, Stanford University, type).

It is a great pleasure for me to dedicate this species to Dr. Francis W. Pennell, foremost American student of the Scrophulariaceae and authority on *Penstemon*.

Penstemon Pennellianus has a coherent distribution in the northern Blue Mountains where it apparently does not associate with its nearest relatives. *Penstemon speciosus typicus* is found to the north, west and south of the region, but at lower elevations. *Penstemon payettensis* Nels et. Macbr. is found to the south in the Wallowa Mountains, Oregon, but much more abundantly farther southeasterly in Idaho. From its characters and distribution it seems possible that *P. Pennellianus* may have arisen through hybridization of these two species. If so it would closely parallel the case of *P. neotericus* Keck, an amphidiploid derivative of *P. azureus* Benth. and *P. laetus* Gray.[2] The question will remain open until some student studies the chromosome situation in *Pennellianus* and *payettensis* (*speciosus* has 8 pairs), or possibly until the attempt is made to synthesize *Pennellianus* from the others.

The facts favoring the hypothesis of a hybrid origin for *P. Pennellianus* are briefly these: (1) *Pennellianus* occupies an area between *speciosus* and *payettensis* into which they do not encroach; (2) it represents a recombination of the characters of these species; (3) *speciosus* and *payettensis* overlap in their distribution giving opportunity for hybridization. The new species combines

[2] Clausen, J. Cytological evidence for the hybrid origin of Penstemon neotericus Keck. Hereditas **18**:65-76, 1933.

the leaf-shape and calyx-lobes of *payettensis* with the characteristic anther-shape and -size of *speciosus*, but the anthers are pubescent like those of *payettensis*. It is more or less intermediate in stature and corolla-size between the two.

Although there is considerable resemblance between *P. Pennellianus* and *P. speciosus* subsp. *lemhiensis*, which extends even to the calyx-lobes and anthers, I believe there is not necessarily a close phylogenetic connection between the two units, but that they had independent and dissimilar origins.

Penstemon cyananthus Hook. subsp. **compactus** subsp. nov.

Caudice suffrutescente; caulibus 10-25 cm altis glaberrimis; foliis superioribus 3-5 (-6) cm longis 12-18 mm latis; thyrso continuo compacto; calyce 6-11 mm longo plus minusve glanduloso glandulis parvis sessilibus vel substipitatis, segmentis lanceolatis vel ovatis longe attenuatis margine membranaceis moderate erosis; corolla 20-26 mm longa 7-10 mm lata glaberrima; staminodio subglabro vel apice barbulato.

UTAH. Cache Co., Bear River Range: Stony slopes of Mt. Naomi, east exposure, 2900 m elevation, August 18, 1938, *Bassett Maguire 16148* (Utah State Agricultural College Herb., type; isotype CI); stony slopes along trail to Mt. Naomi, above Tony Grove Lake, 2590 m, *Maguire 16134* (CI, Utah State); between Mt. Naomi and Mt. Magog, 2775 m, *Maguire, Hobson & Maguire 14158* (CI, Utah State), the same, 2680 m, *14126* (CI, Utah State), the same, color form, flowers lavender-purple when dried, *14148a* (Utah State); east slope of Mt. Magog, 2900 m, *Maguire, Hobson & Maguire 14054* (CI, Utah State); Logan Canyon, 2285 m, June 18, 1924, *Flowers* (Univ. Utah); Cottonwood Ridge, Logan Canyon, 2050 m, *Flowers 763* (Univ. Utah). Cache Co., Wellesville Range: Wellesville Peak, 2740 m. *Flowers 201* (Univ. Utah).

As shown by the above citations, this well marked subspecies has been collected thus far only in the two northernmost branches of the Wasatch Mountains, in Cache County, Utah. It was noted by Maguire to occur in the Canadian and Hudsonian life zones and at higher elevations than typical *P. cyananthus*, although in certain localities the two forms were observed to occur close together. He found the transition in the field from the tall, typical *cyananthus* to the dwarf subsp. *compactus*, with its alpine appearance, both very abrupt and striking.

The new subspecies differs from typical *cyananthus* principally in its low stature, narrower leaves, glandular and excessively elongated sepals, and the feebly bearded staminode. The amount of glands on the calyces and pedicels is a variable feature; in some specimens they are rather obscure. The increased woodiness of the caudex and the more compact inflorescence are features correlated with the subalpine distribution of the subspecies. Its flowers are large for the average of *cyananthus*, but in this species the size of corollas and calyces is variable. For these reasons, and because recombinations of *compactus* characters, such as those of the staminodal beard and the shape of the calyx-lobes, have been found in typical *cyananthus* of northern Utah, the new unit cannot be considered of more than subspecific importance.

PENSTEMON LENTUS Pennell, Contr. U. S. Nat. Herb. 20:359, 1920.—This beautiful member of the *P. secundiflorus* complex remains infrequently

collected. It is known to me only from the following collections. COLORADO. Montrose Co.: Naturita, *Payson 340* (F, M, RM, SU). San Miguel Co.: Placerville, *Payson 3856* (M, RM). Mineral Co.: Caldwell Creek Trail, *Murdoch 4575* (US). Archuleta Co.: Arboles, *Baker 596* (NY, type; isotypes M, RM, US). Montezuma Co.: Mancos, *Eastwood* (NY); above Lookout Mountain Road, Mesa Verde National Park, *Bader* 113 (RM). ARIZONA. Apache Co.: Luka-Chukai Mts., *Goodman & Payson 2882* (CI). So far as known all of the above collections had purple-blue flowers when fresh, but this has not been checked in the Arizona collection, which was taken in fruit.

In the Abajo Mountains of San Juan County, Utah, a white-flowered subspecies has become isolated. This appears to differ from the Colorado material only in flower color, but it was noted by Dr. C. L. Porter, of the University of Wyoming, who called my attention to its existence, to be widespread on Elk Ridge near the "Bear's Ears," on the road west of Blanding. He saw much of this white-flowered plant but no blue-flowered material in the whole region. It is named as follows:

Penstemon lentus subsp. **albiflorus** subsp. nov.

A specie differt: corollis albis. Type: *C. L. Porter 1801* (Rocky Mountain Herbarium), collected in the Abajo Mountains, about eight miles west of Blanding, San Juan Co., Utah, near the "Bear's Ears," at 2440 m. elevation, June 9, 1939. Isotype, CI. A second collection from the same region, taken on Elk Ridge, in the oak belt, at 2590 m. elevation, *K. E. Weight H-85* (CI), appears likewise to have been white-flowered when fresh. The specimen cited by Pennell under his original description of the species, from Monticello, *Rydberg & Garrett 9209*, in part (NY), has not been checked for flower-color.

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The Arctostaphylos canescens Complex*

Beryl O. Schreiber

The species of the genus *Arctostaphylos*, like those of most polymorphic genera, show obvious relationships and aggregate themselves into well defined groups. One such group centers around *Arctostaphylos canescens* Eastwood. Certain species show definite affinities with *A. canescens* and yet are sufficiently distinct to be separated specifically from it. The particular character which brings out this relationship most strongly is that of the nascent inflorescence. In the *A. canescens* complex the nascent inflorescence, whether drooping or erect, is campanulate. They are borne on stout peduncles, which tend to be arcuate or recurved, frequently giving the appearance of a "goose neck" (Plate 1, figs. 1-6). An extensive examination of fresh and dried specimens of *Arctostaphylos* has revealed no other group which shows this peculiar type of peduncle. The bracts of the inflorescence are foliaceous and lanceolate. The whole structure is canescent, with some individuals possessing bristly hairs on the margin of the bracts. These characteristics give to the *A. canescens* group a definite aspect which renders it readily distinguishable from other species of *Arctostaphylos*.

The canescence is not restricted to the inflorescence, but occurs also on the foliage, giving the species of this group a distinctive silvery appearance, which serves as another diagnostic feature when used in conjunction with other characters. The shrubs are still definitely gray-green, although the leaves may be glabrate occasionally. Many of the specimens appear less pubescent in dried material than when fresh.

In no case has this group been known to form burls at the base such as are found in the species centering around *A. glandulosa* Eastw. and *A. tomentosa* (Pursh) Lindl. Repeated field observations show that the group under discussion does not sprout after fire and is, therefore, completely killed.

The species of this complex occur in the Coast Ranges from San Luis Obispo County, California, northward to southern Oregon. They inhabit chiefly the inner ranges, away from the redwood belt, or ecological islands lying within the redwood belt. The extensive field work carried on by the Vegetation Type Map Survey has revealed neither *A. canescens* nor its related species in southern California or in the Sierra Nevada.

The following symbols represent the herbaria of the various institutions consulted: VTM, Vegetation Type Map Herbarium; UC, University of California; D, Dudley Herbarium, Stanford University; CA, California Academy of Sciences, San Francisco; SA, Rancho Santa Ana, Anaheim, California; P, Pomona College, Claremont, Cali-

* Contribution no. 3 from the Vegetation Type Map Herbarium of the Forest Survey Division of the California Forest and Range Experiment Station. The author is Supervising Botanist, Project no. 365-03-3-35 conducted under the auspices of the Works Progress Administration.

fornia. Specimens were also examined at the United States National Herbarium, Gray Herbarium of Harvard University, and New York Botanical Garden. Grateful acknowledgment is due Mr. A. E. Wieslander, California Forest and Range Experiment Station; Dr. H. L. Mason, Department of Botany, University of California; Dr. Daniel I. Axelrod, Smithsonian Institution, Washington, D. C.; and others, for their kind assistance.

Arctostaphylos canescens Eastwood

A. canescens Eastw., Proc. Cal. Acad., ser. 3, 1:84. 1897.
A. strigosa Howell, Fl. N. W. Amer. 1:417. 1901.
A. bracteata Howell, Fl. N. W. Amer. 1:417. 1901.

Erect shrub, occasionally low and spreading on poor sites; 3-24 dm. tall, or to 36 dm. tall, bark smooth, dark purplish red; no burl formation at base; branchlets white-canescent; leaves ovate, oblong or oval, 1.5-3.7 cm. long, 1.0-2.5 cm. wide, the larger leaved northern California forms to 5 cm. long and 3.5 cm. wide, on petioles 4-9 or 12 mm. long, rounded or truncate at base, acute, apiculate or occasionally obtuse at apex; margins entire; leaves gray-canescent; nascent inflorescence (Plate 1, fig. 1) campanulate 6-10 mm. long, 2-4 in a cluster, erect, recurved or spreading, borne on arcuate peduncles 5-10 mm. long; bracts foliaceous, lanceolate, 5-9 mm. long, canescent; flowers white or pinkish, on pubescent, or glandular-pubescent pedicels 4-5 mm. long; ovary densely white-hairy; fruits orange-brown, globose, slightly flattened, 8-10 mm. wide, hairy or glandular-hairy.

Type locality.—Eldridge Grade to Larsen's "between the last bunch of Cypresses and the Rock Spring." South slopes of Mt. Tamalpais, Marin County, California, *Alice Eastwood* (CA).

Distribution.—Loma Prieta, Santa Cruz County, California, northward into southern Oregon. In chaparral *A. canescens* is associated with *Adenostoma fasciculatum, Lotus scoparius, Arctostaphylos glandulosa, Pickeringia montana, Photinia arbutifolia, Quercus Wislizenii, Q. dumosa, Ceanothus cuneatus.* In timbered areas of northern California *A. canescens* is associated with *Pinus ponderosa, Pseudotsuga taxifolia, Pinus Lambertiana, Quercus Kelloggii, Arbutus Menziesii, Arctostaphylos manzanita.*

Specimens to verify range: California. Santa Cruz Co.: Fontenay Villa, *R. C. Wilson 280* (VTM 18723), Lomita Ridge, *Wieslander 297* (VTM 3375); Bodfish Drainage, *Clar & Hagge 41* (VTM 791); Land's End, *Wieslander 699* (VTM 17277). Santa Clara Co.: Loma Prieta, *Schreiber 2578* (VTM 23768); Wright's, *Sindel 384* (VTM 12744); Mt. Umunhum, *Belshaw 2241* (VTM 16137). Marin Co.: Mt. Tamalpais, *Wieslander 854* (VTM 23946); West Peak, Mt. Tamalpais, *H. L. Mason 2670* (UC); West Point Trail, Mt. Tamalpais, *Eastwood 3160* (CA, UC); Eldridge Grade to Larsen's, Mt. Tamalpais (topotype), *L. R. Abrams 11570* (D, UC). Sonoma Co.: Hooke Canyon, *Wieslander 872* (VTM 23981); Los Alamos School, *R. W. Lundh 119* (VTM 1229). Napa Co.: Mt. St. Helena, *Wieslander 712* (VTM 17290); Toll House Canyon, Mt. St. Helena, *Mason 2612* (UC). Lake Co.: Bartlett Mt., *Wieslander 843* (VTM 23935); Adams' Springs, *Wieslander 337* (VTM 3371); Pinnacle Rock, *K. E. Bradshaw 5* (VTM 20483); Calistoga to Middletown, *Wieslander 372* (VTM 3501); Cobb Post Office, *Wieslander 715* (VTM 17293); Hoberg's, *Wieslander 859* (VTM 23951); Near Lakeport, *Bradshaw 58* (VTM 20528); Snow Mt., *Milo S. Baker 3114b* (UC); Near Kelseyville, *J. E. Adams 846* (UC); Upper Lake via Clover Creek Road, *Mason 2578* (UC); Oat Hill Mine,

Ira L. Wiggins 6735 (UC, D). Mendocino Co.: Hull Valley, *H. A. Jensen 256* (VTM 2420); Pine Ridge, *H. S. Yates 3597* (VTM 2415); William's Valley, *Yates 3512* (VTM 1747); Potter Valley, *C. A. Purpus 1001* (UC); Red Mt., *Eastwood* March 30, 1901 (UC, CA); Little Red Mt., *Jepson & Tracy 10297* (UC); Osbornes, *Eastwood 15343* (UC, CA); Cummings, *J. Burtt Davy 5316* (UC). Humboldt Co.: Horse Mt., *Tracy 14064* (UC); Hoopa Mt., *Tracy 8058* (UC). Trinity Co.: Van Duzen River, *Jensen 229* (VTM 782); Harrison Gulch, *P. L. Johannsen 176* (VTM 1398). Shasta Co.: Bohematash Mountain, *Wieslander 485* (VTM 7568); Weaverville, *Johannsen 145* (VTM 2397). Del Norte Co.: Near Monumental, *Parks & Tracy 11373* (UC); Between Smith River & Elk Creek, *Parks & Tracy 12069* (UC). OREGON. Josephine Co.: Hayes Hill, *Adams 1078* (UC).

Arctostaphylos canescens is a species occurring commonly north of San Francisco Bay, but reported from only three localities south of the bay on Lomita Ridge, Loma Prieta Mt., and Mt. Umunhum in Santa Clara County.

There are two forms of this species, which differ in aspect, but no definite characters have been discovered to separate them. One form occurs in a chaparral association on thin-soiled sandstone outcrops. On these sites the plants are low or sprawling shrubs with comparatively small leaves. North of Tamalpais and into southern Oregon the shrubs are tall, erect, with large leaves and are usually associated with *Pinus ponderosa* Dougl. The fruit and flower pedicels are occasionally glandular in both these forms. These larger robust shrubs were described by Thomas Howell as *A. strigosa* and *A. bracteata* (8) respectively. In this northern area where a brush association has replaced the coniferous forests the shrubs of *A. canescens* approach the chaparral form. The species often tends to become erect and have larger leaves in the chaparral areas where the soil is deeper and the shrubs are protected by taller chaparral species. Intermediates between the two forms are therefore frequent. Since it is difficult to point out any sharp distinction between the two forms, they are both retained in *A. canescens*.

The position of *A. canescens* has not been well understood previously. There has been a tendency to combine *A. canescens* with *A. tomentosa* (1) or the pubescent-leaved forms of *A. glandulosa*. This has resulted in the confusion of the pubescent *A. glandulosa* forms in southern California with *A. canescens* in various herbaria. Jepson in his treatment (9) thus cites *A. canescens* as occurring south to San Diego County. All of the forms of *A. glandulosa* exhibit burl formation at the base and therefore sprout after fires, whereas *A. canescens* does not form burls and is killed by fire. The only other southern California species with which *A. canescens* might be confused is *A. otayensis* Wieslander & Schreiber, a non-sprouter, from Otay Mountain in San Diego County (12). In the latter species the foliage is pubescent rather than canescent, and the nascent inflorescence is distinctly different (Plate 1, compare figs. 1 & 9).

Although extensive field work has been carried on in the Mount Hamilton region by the Vegetation Type Map Survey and by Mrs. H. K. Sharsmith, who is studying the flora of that area, no collections of *A. canescens* have as yet been made. Mrs. Sharsmith suggests that the non-occurrence of *A. canescens* in the Mt. Hamilton region may be due to the fact that the chaparral is more xerophytic than are the comparable shrub associations of

Loma Prieta Peak and Mt. Tamalpais. Jepson intimates its occurrence on Mt. Hamilton by citing *A. Campbellae* Eastw., type locality Mt. Hamilton, as a synonym of *A. canescens* (9). This species, however, must be referred to *A. glandulosa* rather than *A. canescens,* because it forms a burl at the base. McMinn also considers *A. Campbellae* to be related to *A. glandulosa* and reduces it to varietal rank under that species as *A. glandulosa* var. *Campbellae* (Eastw.) Adams ex McMinn (11)

Arctostaphylos glutinosa sp. nov.

Frutex globosus griseus, 6-12 dm. altus; cortex levis atroruber; caudex etumescens; ramuli incana minute glandulosi plerumque hispidi pilis albis; folia dense sparseve viriduli-canescentia ovata oblongave, 2.0-4.5 cm. (5 cm.) longa, 1.0-2.5 cm. lata, sessilia petiolatave basi cordata auriculatave, apice acuta obtusave, marginibus integris vel medio ad basim dentatis, saepe utroque latere basis auriculatae dente unico; petioli ad 4 mm. longi; inflorescentia nascens 1-3, apicibus ramulorum, campanulata patens recurvatave, 10-20 mm. longa; pedunculi 3-12 mm. longi; bracteae foliaceae canescentes lanceolatae, 7-12 mm. longae, marginibus hispidociliatis; flores puniceo-albi 6-7 mm. longi; pedicelli glandulosi, 5 mm. longi; ovarium dense glanduloso-pilosum; drupa pallido-cinnamomea globosa, diametro 9-14 mm., dense stipitato-glandulosa.

Round gray shrub 6-12 dm. high, bark smooth, dark red; no burl at base; branchlets densely white-canescent, minutely glandular, and usually with long white bristles; leaves ovate to oblong or oblong-ovate, 2.0-4.5 or 5.0 cm. long, 1.0-2.5 cm. wide, sessile or on petioles to 4 mm. long, cordate or auriculate at base, acute or apiculate at apex, margin entire or toothed from the middle to base, often with large tooth at the auricled base, leaves densely canescent to lightly canescent, gray-green, nascent inflorescence (Plate 1, fig. 2) campanulate, spreading or recurved, 1-3 borne at the tips of the branches, 10-20 mm. long on peduncles 3-12 mm. long, bracts foliaceous, lanceolate 7-12 mm. long, gray-canescent, margins white-bristly; flowers pinkish-white, 6-7 mm. long on glandular-hairy pedicels 5 mm. long; ovary densely glandular-hairy; fruits light orange-brown, globose 9-14 mm. wide, densely stipitate-glandular.

Type.—Nascent inflorescence; 2 miles S.S.W. of Eagle Rock, Santa Cruz County, California, 1900 feet elevation, July 16, 1939, *A. E. Wieslander 890* (VTM 25225); flowering and immature fruiting specimen; N. side Mill Creek, 2½ miles S.W. of Eagle Rock, Santa Cruz County, California, 2100 feet elevation, April 2, 1939, *Beryl Schreiber 2599A* (VTM 24013); fruiting specimen: 2 miles S.S.W. of Eagle Rock, Santa Cruz County, California, 1900 feet elevation, July 16, 1939, *Wieslander 891* (VTM 25226).

Distribution.—Monterey shale hills, west of Bonnie Doon Ridge, Santa Cruz County, California, 1900-2100 feet elevation, associated with *Pinus attenuata, Arctostaphylos glandulosa, Adenostoma fasciculatum, Dendromecon rigida,* and *Quercus chrysolepis nana.*

Arctostaphylos glutinosa is a dominant species in the chaparral on the Monterey shale deposits draining into Mill Creek Canyon. Although this

shale formation, known as The Chalks, is quite extensive in Santa Cruz County, it was carefully checked by Kenneth Bradshaw of the Vegetation Type Map Survey, and this species was found only in this area.

It may be distinguished from the other dominant, *A. glandulosa,* by the fact that it does not sprout from a burl at the base, and by the gray-canescent foliage, as well as by the nascent inflorescence (Plate 1, compare figs. 2 & 7) and the common occurrence of auriculate, sessile-leaved forms. The latter character, and the glandular fruits might suggest a relationship with *A. Andersonii* Gray, which occurs in the woodland sections of the adjoining ridge. Here again the nascent inflorescence and canescent foliage serve to separate *A. glutinosa* from *A. Andersonii* (Plate 1, compare figs. 2 & 10).

A. silvicola, which belongs to the *A. canescens* complex, occurs in Santa Cruz County on Mt. Hermon Ridge and on a section of Bonnie Doon Ridge. The cordate, or auriculate, ovate, or ovate-oblong leaves, and stipitate-glandular fruits readily distinguish *A. glutinosa* from *A. silvicola* which has lanceolate leaves, cuneate or rounded at the base, and glabrous or sparsely hairy fruits. They occur in situations quite different ecologically, *A. silvicola* growing on a marine sand formation under *Pinus ponderosa* and *A. glutinosa* on Monterey shale in chaparral.

Arctostaphylos obispoensis Eastwood

A. obispoensis Eastw., Leafl. West. Bot. 2:8. 1937.

Erect shrub, often with a distinct trunk; 12-45 or 60 dm. high; bark smooth, dark purplish-red; no burl at base; branchlets soft-tomentose or canescent; leaves ovate to oblong-ovate; 2.0-4.5 cm. long, 1-3 cm. wide, sessile, or on petioles up to 7 mm. long; truncate to cordate or auriculate at base, occasionally rounded; acute, apiculate, or obtuse at apex; margin entire or occasionally serrulate at base; leaves gray-canescent, rarely glabrate; nascent inflorescence (Plate 1, fig. 3) campanulate, usually erect, 10-15 mm. long, 2-3 borne on arcuate peduncles 5-10 mm. long, bracts foliaceous, lanceolate 7-14 mm. long, canescent; flowers white or pink-tinged, 6-8 mm. long on glabrous pedicels; ovary sparsely hairy; fruit pale orange-brown to red-brown, depressed-globose, to 10 mm. wide, glabrous, or sparsely hairy.

Type locality.—Serpentine area up Chorro Creek, near San Luis Obispo, California, *A. Eastwood 16843* (in flower); *15125* (in fruit) (CA).

Distribution.—Serpentine outcrops, San Luis Obispo County and southern Monterey County, California, 300-2700 feet elevation, associated with *Pinus Sabiniana, Quercus durata, Cupressus Sargentii, Photinia arbutifolia, Ceanothus cuneatus* (form), *Salvia mellifera, Diplacus aurantiacus.*

Specimens to verify range: California. San Luis Obispo Co.: Chorro Creek, *Schreiber 2553* (VTM 23729); Pine Mt., *R. St. John 324,* (VTM 1189); Burnett Peak, *Wieslander 275* (VTM 2470); Goldtree, *B. Bolt 546* (VTM 13788); Morro Creek, *Wieslander 616* (VTM 13816); Cuesta Grade, *Wieslander* 643 (VTM 15472); Chorro Creek, *Eastwood 15125* (UC, CA, D); Cuesta summit, April 11, 1908, *J. J. Condit,* (UC); Santa Margarita Mts., January 5, 1905, *W. R. Dudley,* (D); Chrome Mine Road, January 2, 1908 *Dudley,* (D); Manzanita Mt., April 3, 1902, *Dudley,* (SA). Monterey Co.: Krenkel's Ranch, *St. John* 319 (VTM 1190).

Arctostaphylos obispoensis is, so far as known, the southernmost of the species affiliated with *A. canescens*. It is limited to serpentine outcrops, or to areas in San Luis Obispo and southern Monterey counties where decomposed serpentine has filtered into the soil.

At the type locality on Chorro Creek all of the shrubs have petiolate leaves, cordate or truncate at base, whereas in the Cuesta Pass area the leaves are sessile and auriculate. However, on the slope from the type locality to Cuesta Ridge, occur various intergradations which indicate that these auriculate, sessile-leaved types are of the same species as the petiolate, truncate, or cordate-leaved types. A similar situation exists in *A. glutinosa* in Santa Cruz County, where some of the shrubs show petiolate, cordate leaves and others in the same area have auriculate, sessile leaves. The occurrence of auriculate, sessile, and petiolate leaves in the same species indicates that this character cannot be considered a valid criterion for relating certain groups of *Arctostaphylos*, as has been done previously. In the southern portion of the range of *A. obispoensis* the leaves tend to be all sessile and auriculate, whereas in the northern part of its range the leaves are more commonly petioled and cordate at the base, but the two forms intermingle in the Cuesta Pass area.

The auriculate-leaved forms of *A. obispoensis* have frequently been confused with *A. pechoensis* Dudley, which bears similar leaves. However, it is conceivable that this confusion occurred because of an error in the original description of *A. pechoensis*, which states that the branchlets are finely tomentose (1), whereas the type specimen shows the branchlets to be densely covered with bristles. Wieslander states that he has observed the shrubs at the type locality, and the writer has seen plants nearby in the Pecho hills, and neither of us has seen a shrub with finely tomentose branches, all of the plants having at least some long coarse bristles. Although Jepson, in his description (9) of *A. Andersonii* var. *pechoensis* (Dudley) Jepson, mentions the branchlets as "puberulent and bristly (as in the type collection) or merely tomentose," other authors have ignored the fact that the type collection has bristly hairs. The auriculate-leaved forms of *A. obispoensis* on Cuesta Pass and south of that area have finely tomentose branchlets and have therefore been referred to *A. pechoensis*.

The typical *A. canescens* type of inflorescence and the gray canescent foliage relate to *A. obispoensis* to *A. canescens*. The original description makes no mention of the auriculate, sessile leaves, but field observations have indicated that the description must be emended to include these auriculate-leaved forms. The above characters are sufficient to distinguish *A. obispoensis* from *A. pechoensis*, because the latter species has leaves which are glabrous and glaucous or only slightly pubesecnt on the under surface, a distinctly different nascent inflorescence (Plate 1, compare figs. 3 & 11), and is not confined to serpentine.

Arctostaphylos auriculata Eastwood

A. auriculata Eastw., Bull. Torr. Bot. Club 32:202. 1905.
Uva-ursi auriculata (Eastw.) Abrams, N. Am. Fl. 29:98. 1914.
A. Andersonii Gray var. *auriculata* (Eastw.) Jepson, Madroño 1:88. 1922.

Low shrub to erect arborescent forms with distinct trunk, 24-45 dm. high, bark smooth, dark red; no burl at base; branchlets short-pubescent and bristly-hairy; leaves ovate to oblong-ovate 2-5 cm. long, 1-4 cm. wide, sessile or subsessile, auriculate at base; apex acute or rounded, margin entire or serrate at base, leaves finely white-canescent, gray-green; nascent inflorescence (Plate 1, fig. 4) campanulate, erect or spreading, 1-3 at the tips of branches, 12-15 mm. long, on arcuate peduncles 10-15 mm. long, bracts foliaceous, linear, or linear-lanceolate, 6-10 mm. long, white-canescent, margins occasionally white-bristly; flowers white or pinkish, 6 mm. long on pubescent pedicels 5 mm. long; ovary densely white-hairy; fruit red-brown or orange-brown, 5-7 mm. wide, pubescent.

Type locality.—Trail above the Boyd Ranch, Mt. Diablo, Contra Costa County, California, *Eastwood* (CA).

Distribution.—On sandstone, Mt. Diablo region, Contra Costa County, California, associated with *Adenostoma fasciculatum, Eridictyon californicum, Arctostaphylos glandulosa, Arctostaphylos manzanita, Ceanothus cuneatus.*

Specimens to verify range: CALIFORNIA. Contra Costa Co.: Rock City (Mt. Diablo), *Lundh 138* (VTM 1596); Head of Sycamore Creek, *Jensen 455* (VTM 23794); Head of Curry Canyon, *Jensen 450* (VTM 23789); Antioch, *K. Brandegee 7* (UC); 8 miles N. E. of Danville, *L. Rose 34039* (UC, CA); Sycamore Canyon, *M. L. Bowerman 1045* (UC).

Arctostaphylos auriculata occurs in the chaparral in several localities on Mt. Diablo. Its leaves, unlike those of *A. glutinosa* and *A. obispoensis*, are all auriculate, and no petioled-leaved forms have been found.

Most authors have considered this species to be related to *A. Andersonii* because of the sessile, auriculate leaves. Miss Eastwood, however, definitely states that this species belong to the same group as *A. canescens*, although she remarks a resemblance to *A. Andersonii* because of the auriculate leaves and the hairiness of the stems (6). The writer coincides with Miss Eastwood's first statement, as further study of this group has shown a quite evident relationship between *A. canescens* and *A. auriculata*. This evidence is furnished primarily by the nascent inflorescence, *A. auriculata* having the typical inflorescence of *A. canescens*. A marked difference is revealed by the comparison of the nascent inflorescence of *A. Andersonii* with that of *A. auriculata* (Plate 1, compare figs. 4 & 10). The gray-canescent foliage of *A. auriculata* contrasts with the glabrous or lightly puberulent foliage of *A. Andersonii*.

There remains then only the mutual possession of auriculate leaves and hairy branchlets to bind together the two species. The occurrence of both auriculate and petioled leaves in *A. obispoensis* and *A. glutinosa*, both members of the *A. canescens* group, weakens the strength of the auriculate leaf character. Furthermore, although the branchlets of *A. glutinosa* are usually hairy, occasionally individuals may be merely canescent. It is concluded, therefore, that there is insufficient justification for reducing *A. auriculata* to varietal status under *A. Andersonii* and that the evidence points to its alliance with the *A. canescens* complex.

Arctostaphylos sonomensis Eastwood

A. sonomensis Eastw., Proc. Cal. Acad., ser. 3, 1:84. 1897.
A. canescens Eastw. var. *sonomensis* Adams ex McMinn, Man. Calif. Shrubs, 409. 1939.

Rounded gray shrub 9 to 18 dm. high, and often up to 30 dm.; bark smooth, dark red, no burl at base; branchlets white-canescent; leaves lanceolate or ovate-lanceolate, 2.0-4.5 cm. long, 0.8-2.5 cm. wide on petioles 3-7 mm. long; cuneate or rounded at base, acute at apex, margin entire; leaves densely gray-canescent to occasionally glabrate; nascent inflorescence (Plate 1, fig. 5) campanulate, spreading or recurved, 1-3 borne at the tips of the branches, 10-15 mm. long on peduncles 3-10 mm. long, bracts foliaceous, lanceolate, 4-12 mm. long, gray-canescent, minutely glandular; flowers white; 6-7 mm. long on pubescent, or glandular-pubescent pedicels 4-5 mm. long; ovary densely pubescent, occasionally slightly glandular; fruit pubescent or somewhat glandular-pubescent.

Type locality.—On Rincon Ridge near Santa Rosa, Sonoma County, California, *Milo S. Baker 3877c.* (CA).

Distribution.—Rincon Ridge, Sonoma County, California, on volcanic soil, associated with *Quercus Wislizenii, Arctostaphylos manzanita, T. Stanfordiana, A. glandulosa, Adenostoma fasciculatum, Pickeringia montana.*

Specimens to verify range: California. Sonoma Co.: Rincon Ridge, *Belshaw 1577* (VTM 13745); S. edge of Rincon Hills, *Wieslander 877* (VTM 23986); Rincon Ridge, *Adams 1024* (UC).

Arctostaphylos sonomensis is an extremely local species known only on Rincon Ridge in chaparral. It closely simulates *A. silvicola* of the Santa Cruz mountains in leaf form, the leaves tending to be lanceolate or ovate-lanceolate and cuneate or occasionally rounded at the base. The geographic location, minutely glandular-pubescent branchlets, pubescent ovary and fruits, however, separate this plant from *A. silvicola,* which has merely canescent branchlets, glabrous or sparsely hairy ovary and fruits.

Of all the species in the *A. canescens* complex *A. sonomensis* is the only local endemic which closely approaches the northern forms of *A. canescens* geographically. The narrow leaves, however, distinguish it from *A. canescens* (9); although others consider it a variety (11), it is here retained as specifically distinct, inasmuch as no apparent intergrades with *A. canescens* have been found in that or any other locality.

Arctostaphylos silvicola Jepson & Wieslander

A. silvicola Jepson & Wieslander, Erythea, 8:101. 1938.

Silvery-gray shrub, 20-25 dm. high; no burl formation at base; bark smooth, deep dark red; branchlets densely gray-canescent with soft hairs; leaves lanceolate to oblong-lanceolate, obtuse or apiculate at the apex, rounded-cuneate at the base, densely gray-canescent, or occasionally glabrate, 15-40 mm. long, on petioles 3-8 mm. long; nascent inflorescence (Plate 1, fig. 6) short, 9-13 mm. long, sessile or on peduncles 2-4 mm. long, campanulate, pendulous or slightly

spreading, 1-3 in a cluster, bracts leafy, lanceolate, 4-12 mm. long, the tips slightly recurved, densely canescent, gray-green, pink-tinged; flowers white, 5-6 mm. long, on glabrous or hairy pedicels; ovary glabrous or rarely hairy; berry globose, slightly depressed at the apex, 5-10 mm., orange-brown, glabrous, rarely slightly hairy; nutlets separate.

Type locality.—Mount Hermon Ridge, Santa Cruz County, California, *Wieslander.*

Distribution.—Ridges above Mount Hermon and Bonnie Doon, Santa Cruz County, California, on marine sand deposits, associated with *Pinus ponderosa, Arctostaphylos tomentosa, Adenostoma fasciculatum,Ceanothus* sp., *Haplopappus ericoides* subsp. *Blakei,* and *Lupinus albifrons.*

Specimens to verify range: CALIFORNIA. Santa Cruz Co.: Mount Hermon, *Wieslander 701* (VTM 17279); Near Bonnie Doon, *Yates 5020* (VTM 8019); Big Trees, *C. W. Hanks 169* (VTM 8730); Mount Hermon, *McMinn 1699* (D); Ben Lomond, *Elmer 4606* (D, P, CA); Near Tuxido, April 17, 1904, *Dudley* (D, CA); Scott's Valley, *Abrams 10903* (D); Glenwood, February 7, 1914, *Horace Davis* (CA); Twin Oaks Ranch near Eccles, June 27, 1897, *Dudley* (D, CA).

Arctostaphylos silvicola occurs on marine sands in chaparral under *Pinus ponderosa,* or in nearly pure stands as a fire type replacement of this pine (12). *A. silvicola,* like the other members of the *A. canescens* complex, can be considered a distinct unit because of its geographic isolation. There are, however, other characters which separate this species from the other components of the *A. canescens* group. The differences between this and *A. glutinosa,* the species nearest related geographically, have already been discussed. It may be distinguished from the chaparral form of *A. canescens* of Loma Prieta Peak by its taller and more erect habit and its narrow lanceolate leaves. The ovary and fruit of *A. silvicola* are glabrous, or rarely hairy, whereas the ovary of *A. canescens* is densely hairy and the fruit usually pubescent or slightly glandular.

The only other species of the *A. canescens* group with which *A. silvicola* might be confused is *A. sonomensis.* In addition to those distinguishing characters which have been previously discussed under *A. sonomensis,* it is remote geographically.

Another species, *A. tomentosa,* occurs in the same area with *A. silvicola,* but it is readily separated from it by its capacity to sprout, and by its green foliage, hairy branchlets and nascent inflorescence (Plate 1, compare figs. 6 & 8).

The differences between the six species considered to belong to the *Arctostaphylos canescens* complex may best be shown by the following key.

Branchlets with long or short bristly hairs; bracts of nascent inflorescence with white bristles on margins.
- Leaves auriculate and sessile or short-petioled and cordate at base; flowers on glandular-hairy pedicels; ovary densely glandular-hairy; fruit stipitate-glandular, 9-14 mm. wide; Monterey shale, Santa Cruz County. ..... *A. glutinosa*
- Leaves all auriculate and sessile; flowers on pubescent pedicels; ovary densely white-hairy; fruit pubescent or sparsely so, not glandular, 5-7 mm. wide; sandstone, Contra Costa County. ..... *A. auriculata*

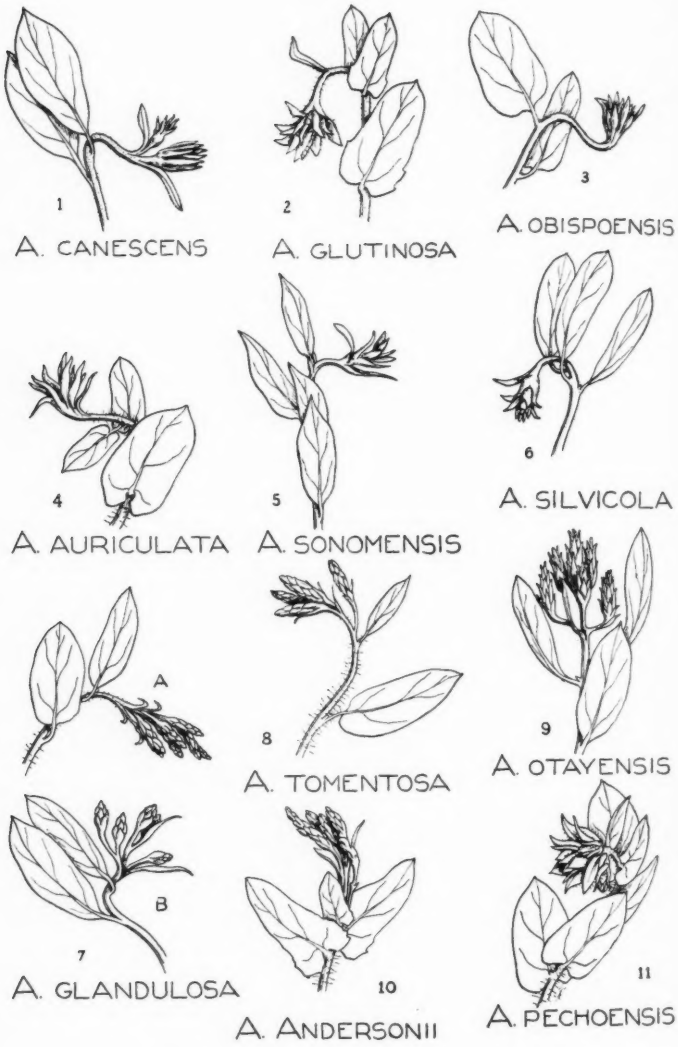

PLATE 1. Nascent inflorescences in *Arctostaphylos*.

Branchlets canescent, no long bristly hairs; bracts of nascent inflorescence with or without bristles on the margins.
  Leaves oblong to ovate or oval; rounded, truncate, cordate, or auriculate at base; sessile or petiolate.
    Leaves rounded, occasionally truncate at base, petiolate; flower pedicels pubescent or glandular-pubescent; ovary densely white hairy; fruit hairy, occasionally glandular; Santa Clara County, California, to southern Oregon. ..... *A. canescens*
    Leaves auriculate and sessile at base or if petiolate then cordate or truncate at base, rarely rounded, Santa Cruz County south to San Luis Obispo County.
      Bracts of nascent inflorescence with bristles on the margin; flowers on glandular-hairy pedicels; ovary densely glandular-hairy; fruit stipitate-glandular; Monterey shale, Santa Cruz County..... *A. glutinosa*
      Bracts of nascent inflorescence without bristles on margin; flower pedicels glabrous; ovary sparsely hairy; fruit glabrous, rarely sparsely hairy; serpentine outcrops, Monterey and San Luis Obispo Counties ..... *A. obispoensis*
  Leaves lanceolate or ovate-lanceolate, cuneate, or occasionally rounded at base, petiolate.
    Branchlets minutely glandular; ovary densely pubescent, often glandular; fruit pubescent, or occasionally glandular-pubescent; volcanic soil, Sonoma County ..... *A. sonomensis*
    Branchlets canescent, not glandular; ovary glabrous, rarely hairy; fruit glabrous, rarely pubescent; marine sands, Santa Cruz County..... *A. silvicola*

In the above key emphasis is placed chiefly upon the vegetative characters which are visible throughout the year, and upon the geographical distribution. The flowering pedicels, and the characters of the ovary and fruit when these structures are present, aid further in the separation of the species. In those species having bristly-hairy branchlets, if these bristles are lacking, as they are in some individuals of *A. glutinosa*, some bristles are usually present on the margins of the bracts of the nascent inflorescence.

By plotting the localities of the six species of the *Arctostaphylos canescens* complex on a map of California (Plate 2), and with a knowledge of the characters of each species, as briefly presented above, certain theoretical deductions present themselves for consideration. These rest primarily on the past and present distribution of the group as related to the development of the species.

There is at present every indication that the genus *Arctostaphylos* was of southern origin. The earliest known record of manzanita is in the early Middle Miocene Tehachapi flora from the western border of the Mohave Desert. This species, *A. mohavensis* Axelrod, which was based on a leaf impression and a nutlet, shows relationship to three modern species, *A. glauca* Lindl. (leaf), *A. Pringlei* Parry, and *A. glandulosa* Eastw. (leaf and nutlet) (4). The next record, referred to *A. prepungens* Axelrod by Axelrod, is from the Lower Pliocene Clarendon beds of Texas (3), an area 500 miles northeast of any living species of *Arctostaphylos* (Mason, mss.; 4, p. 53). The fossil forms of *Arctostaphylos* from the Middle Pliocene Mount Eden beds of southern California have been named *A. prepungens* and *A. preglauca* Axelrod, because of their close resemblance to the species *A. pungens* H.B.K. and *A. glauca* (2). Occurring in southern California at the present time, *A. pungens* is found also in the southwestern United States and Mexico, and *A. glauca*

ranges into Lower California. The most northern Pliocene records of the genus are from the Upper Pliocene Santa Clara formation near Portola on the edge of the Santa Clara Valley, and from the St. Mary's flora in Moraga Valley, a few miles west of Mount Diablo. In the Santa Clara flora the two leaf impressions are referred to "*A. manzanita* or to one of the nominal species grouping with it" (7). In the St. Mary's flora a single leaf impression has been found whose suggested modern equivalent is *A. glandulosa* (Axelrod mss.).

The abundance of *Arctostaphylos* in the Pliocene and Pleistocene formations of southern California suggests that the center of distribution and variation was in southern California during those epochs, for they were more arid than central California at that time. Although the present centers of distribution and variation in the genus are in Monterey, Marin, Napa, and Lake counties, this distribution is considered to be recent in origin owing to the relative scarcity of *Arctostaphylos* material in the northern as compared with the southern Pleistocene floras of coastal California (5, 10). This suggestion of a northward migration of the genus during and since Pliocene, as climatic conditions became drier and warmer at the north, is consistent with evidence of the invasion of central California by a typical California flora during Pliocene time (4, p. 54-55).

During later Cenozoic time the genus *Arctostaphylos* is found associated with coniferous forests. In the Middle Pliocene of southern California the manzanitas are found with such species as *Pinus Hazeni* Axelrod (*P. Coulteri* Don.), *Pinus Pieperi* Dorf (*P. Sabiniana* Dougl.), and *Pinus pretuberculata* Axelrod (*P. attenuata* Lemmon) (2). Significantly, the modern equivalents of these pines are associated today with the members of the *A. canescens* complex. The chaparral species, *A. obispoensis, A. auriculata,* and *A. sonomensis,* often occur in the Digger pine *(Pinus Sabiniana)* forest. *Arctostaphylos glutinosa* and occasionally *A. obispoensis,* as well as the chaparral forms of *A. canescens,* are found with *Pinus attenuata* or *P. Coulteri.* It is also remarked that two of these species occur at the upper limits of the Digger pine and lower limits of the ponderosa pine forests. *Arctostaphylos sonomensis* occurs with both ponderosa pine (*P. ponderosa*) and Digger pine (*P. Sabiniana*) forests on Rincon Ridge, Sonoma County. In southern Monterey County, *A. obispoensis* occurs with *P. Sabiniana* on the edge of what appears to be remnant ponderosa pine stands.

These relationships suggest that the *A. canescens* group may have developed at the south in later Tertiary time in association with the fossil equivalents of the *Pinus Sabiniana, P. attenuata,* and *P. Coulteri* forests. It is possible that in late Pliocene and Pleistocene time *A. canescens* invaded the yellow pine association, which may then have extended farther south as is indicated by the relictual nature of its isolated modern occurrences in southern California. As the climate became warmer and drier at the south, *A. canescens* moved northward. In this migration of the group, variants may have been developed gradually which could find a niche in a chaparral environment more easily than could the taller, larger-leaved forms of *A. canescens.* Although the majority

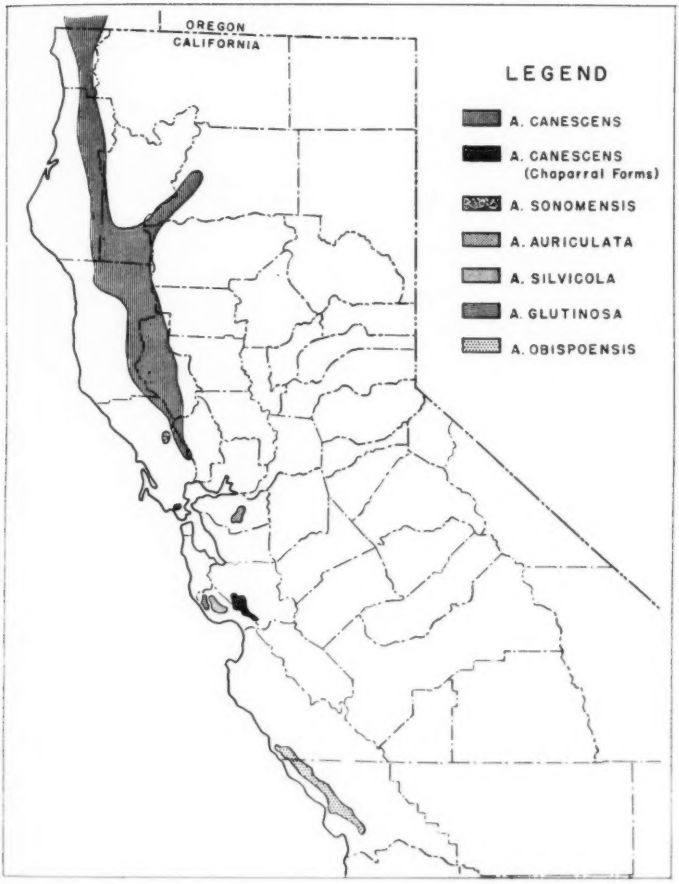

PLATE 2. Map showing the distribution of the species in the *Arctostaphylos canescens* complex.

of the species are in chaparral areas, in many of these localities there is evidence that coniferous forests occupied the ground but recently. This is consistent with evidence of the relatively recent development of the chaparral formation in southern California (4, p. 64-65), with the fact that it is of seral and subclimax character over areas of the modern distribution of the *A. canescens* group, and with the fact that forests covered much of coastal California during Pleistocene.

Although the large-leaved *A. canescens* of the pine forests of the north Coast Ranges is regarded as the ancestral stock from which the other species of the group have differentiated, it is extremely difficult to postulate its origin from any of the known fossil species. Perhaps its nearest relatives in the fossil record are the forms related to *A. glandulosa*. However, the modern *A. glandulosa* forms burls at the base of the trunk and *A. canescens* does not. Since this burl character has been shown to be constant (12), it would seem difficult to assign *A. canescens* to any origin in the *A. glandulosa* group. However, if burl development be of recent origin in the genus, the relationship through *A. otayensis* which may exist between the burl-forming *A. glandulosa* group and the non-burl-forming *A. canescens* complex may be critical. *Arctostaphylos otayensis* is very similar in appearance to some of the pubescent forms of *A. glandulosa* but lacks the burl. The grayish-pubescent foliage and the slight tendency to foliaceous bracts in the nascent inflorescence express a similarity with the *A. canescens* group. Since the species under consideration belong to plastic groups, it seems clear that any one Miocene or Pliocene species, such as the forms referred to *A. glandulosa*, may have given rise to species now in distinct habitats and differing greatly from the original type.

The five endemic species of the group have developed characters which may be used as a basis for their separation. These characters seem due in part to the aridity which prevails in the habitats of the segregates. Specific edaphic requirements may also have been operative in the segregation of species, inasmuch as all are restricted to definite types of soil. The more important relationships and morphological features of the species may be discussed briefly. The genetic connection of the auriculate-leaved types with the petiolate-leaved forms is apparently well-marked. *Arctostaphylos obispoensis* and *A. glutinosa* have both petiolate and auriculate forms, while *A. auriculata* has only auriculate types. Another important character is the occurrence of bristly hairs on the branchlets: *A. obispoensis* has no bristly hairs; in *A. glutinosa* some of the branchlets are bristly and some are not, and *A. auriculata* exhibits bristly hairs on every specimen examined. We may conclude then that *A. auriculata* is related to *A. canescens* through the *A. obispoensis-A. glutinosa* line. *Arctostaphylos silvicola* and *A. sonomensis* may be regarded as two coordinate offshoots with similar lines of divergence from the typical form but whose geographic isolation has permitted independent development (Chart 1). The chaparral forms of *A. canescens* are descendants of the main line, which, under xeric conditions, have assumed a slightly different aspect from the parental type and have not become clearly delimited.

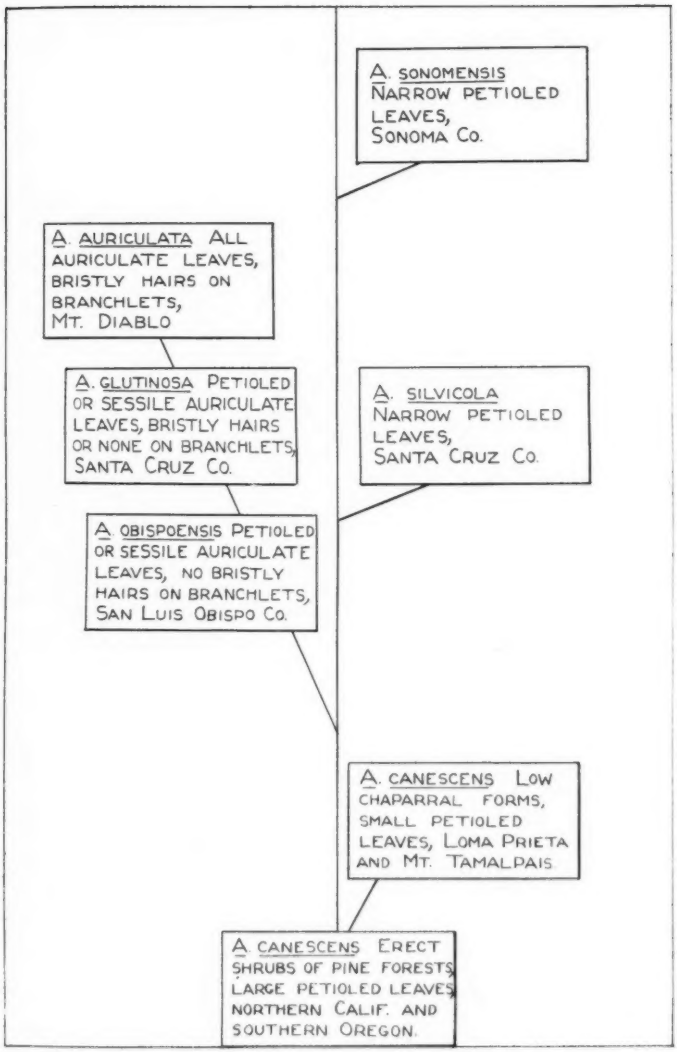

CHART I. Diagram showing relationships of the species of the *Arctostaphylos canescens* complex to *A. canescens*.

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Aristida basiramea and its Relatives

L. H. Shinners

Aristida basiramea, A. Curtissii, and *A. dichotoma* are three closely related annual grasses, extremely variable in size and habit. Previous authors[1] have relied on the short lateral awns to separate *A. dichotoma* and *A. Curtissii* from *A. basiramea.* The size of the awns, however, varies considerably in the last two species, while in the more fundamental characters in the rest of the spikelet there is apparently no constant difference between them. Both, however, are readily separable from *A. dichotoma* by the larger spikelets and very unequal glumes. So closely does *A. Curtissii* resemble *A. basiramea* that it might be considered a form of that species except for a slight difference in range. In view of this difference *A. Curtissii* may be better treated as a variety of *A. basiramea:*

Aristida basiramea Engelmann var. **Curtissii** (A. Gray) comb. n.

A. dichotoma var. *Curtissii* A. Gray, Man. of the Botany of the Northern U. S. ed. 6, p. 640, 1890. *A. Curtissii* Nash in Britton, Man. of the Flora of the Northern States and Canada 94, 1901.

The three plants together with a form of *A. dichotoma* sometimes mistaken for *A. basiramea* var. *Curtissii* may be separated as follows:

Lemma 6.2-10 mm. long; glumes markedly unequal, the first about ½-¾ as long as the second (first glume 5-12 mm. long, second glume 6.2-16 mm. long); first glume shorter than (rarely equalling) the lemma, second glume seldom reaching beyond the middle of the lateral awns; lateral awns 3-11 mm. long.

Lateral awns 5-11 mm. long, ½ or more the length of the central awn. ..... *A. basiramea.*

Lateral awns 3-6 mm. long, less than ½ the length of the central awn. ..... *A. basiramea* var. *Curtissii.*

Lemma 3.5-7.4 mm. long; glumes slightly unequal or equal, the first 5/6 or more the length of the second (first glume 5.2-10 mm. long, second glume 5.8-10.2 mm. long); first glume usually equalling or exceeding the lemma, second glume exceeding the lemma and often reaching the tips of the lateral awns; lateral awns 1-4 or rarely (in forma *major*) 6 mm. long.

Lemma 3.5-6.5 mm. long, second glume 5.8-9.2 mm. long; straight part of central awn 3-6 mm. long. ..... *A. dichotoma*

Spikelets slightly larger, regardless of the size of the rest of the plant: lemma 6-7.4 mm. long, second glume 9.2-10.2 mm. long; straight part of central awn 6 mm. or more long. ..... *A. dichotoma* f. *major.*

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1 G. V. Nash in Britton, Man. of the Flora of the Northern States and Canada 94-95, 1901.

A. S. Hitchcock. N. Amer. Species of Aristida. Contrib. U. S. Nat. Herb. **22**:533-536, 1924.

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J. Th. Henrard, Critical Revision of the Genus Aristida **2**:160-161 Medeelingen s. Rijks Herbarium Leiden **58A**, 1932.

Aristida dichotoma Michx. forma **major** f. nov.

Spiculis forma typica paulo majoribus (plantae totius magnitudine non curato): lemmate 6-7.4 mm., gluma secunda 9.2-10.2 mm., arista media (parte recta) 6 vel plura mm. longitudine. — TYPE collected by T. H. Kearney near Starkville, Mississippi, Sept. 27, 1896; in the Gray Herbarium. Type sheet bears two plants of forma *major* and one of the ordinary form.

The following mostly recent collections may be cited extending the known ranges of these plants. Abbreviations refer to the herbaria of the Milwaukee Public Museum (M), the University of Wisconsin (W), the New York Botanical Garden (N), the Gray Herbarium (G), and the United States National Herbarium (U). Grateful acknowledgment is made to the curators of these herbaria for the loan of specimens.

Aristida basiramea Engelm.

MAINE. Oxford Co.: Bethel, *L. A. Wheeler*, Oct. 10, 1928 (G). NEW HAMPSHIRE. Hillsboro Co.: Moore's Crossing, Bedford, *M. L. Fernald & Ludlow Griscom*, August 27, 1931 (G). NEW YORK. Essex Co.: Open sand plain s. of Keeseville, *Fernald* 2491 (G). St. Lawrence Co.: Russell Pond, South Colton, *W. C. Muenscher & R. T. Clausen* 3976 (G). TENNESSEE. Knox Co.: Knoxville, *A. A. Eaton*, Sept., 1895 (G). MISSISSIPPI. Oktibbeha Co.: Starkville, *S. M. Tracy*, Sept. 22, 1892 (N). WISCONSIN. Green Lake Co.: Near Marquette, *L. H. Shinners*, Sept. 26, 1937 (M). Dane Co.: Picture Rock near Mt. Vernon, *Shinners* 246 (W). COLORADO. Boulder Co.: White Rocks, *Francis Ramaley* 15856 (U). Also listed from Kalamazoo Co. Michigan (F. J. Hermann, Rhodora **38**:363, 1936); specimen not seen.

A. basiramea var. *Curtissii* (A. Gray) Shinners

MARYLAND. Prince Georges Co.: Near Chillum, *S. F. Blake* 9719 (G). WEST VIRGINIA. Mineral Co.: Burlington, *E. E. Berkeley*, August 23, 1928 (U). VIRGINIA. Southampton Co.: About 7 miles s. of Franklin, *Fernald & Long* 7215 (G). Fernald lists the plant from several localities in this region; see Rhodora **39**:382, 1937, and **40**:387, 1938. WISCONSIN. Marquette Co.: Observatory Hill, *N. C. Fassett & W. T. McLaughlin* 14945 (W). Green Lake Co.: Marquette, *Shinners*, Sept. 26, 1937 (W). Dane Co.: Picture Rock, *Shinners* 245 (W). Iowa Co.: Ridgeway, *R. W. Pohl* 1257 (M). OKLAHOMA. Caddo Co.: Five miles s. of Hinton, *M. Hopkins* 2131 (U). Also reported from Minneapolis, Hennepin Co., Minnesota (W. A. Wheeler, Minn. Bot. Studies **3**:89, 1903-1904); specimen not seen.

A. dichotoma Michx.

MICHIGAN. Kalamazoo Co.: Schoolcraft, *C. R. Hanes*, Sept. 22, 1935 (U).

It is difficult to say whether *A. basiramea* is present as a native plant in northeastern United States, somewhat isolated from the rest of its range, or whether it has been introduced there. According to the collectors, it appears native but introduction remains a possibility.[2] Except for these northeastern stations the ranges of *A. basiramea* and its var. *Curtissii* are very similar: both extend northward in the Mississippi valley to Minnesota and Wisconsin, and are found from Maryland southward in the east. *A. dichotoma* on the other hand ranges from Maine to Florida, west to southern Michigan, Illinois, Kansas, and Texas.

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2 See W. C. Muenscher & R. T. Clausen, Notes on the Flora of Northern New York, Rhodora **36**:405, 1934; and L. A. Wheeler, Aristida basiramea in Maine, Rhodora **31**:78, 1929.

A Seasonal Population Study of Pond Entomostraca in the Cincinnati Region[1]

Elizabeth B. Ward

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Introduction

The seasonal history of microscopic Crustacea has been traced through entire annual cycles in relatively few parts of the United States. The work of Marsh (1897) on the limnetic Crustacea of Green Lake, Wisconsin, is one of the first important studies of periodic seasonal conditions. Birge (1898) has published a detailed report on the plankton Crustacea of Lake Mendota, Wisconsin, as observed in over two years of consecutive collections. The extensive work of Kofoid (1908) on the plankton of the Illinois River provides an account of the fluctuations of all plankton organisms, including Crustacea, over a five year period. These investigations and others have treated certain areas with great completeness, but there are many parts of the country where the yearly entomostracan populations are quite unknown.

Observations on Cincinnati Entomostraca have been published by several workers. Chambers (1874) has remarked upon the presence of two species of phyllopods in this general area and has described two species of copepods from northern Kentucky. Hunt (1882) lists nine species of Entomostraca as occurring locally. By far the most extensive work on local representatives of this group is that of Turner (1892, '93, '94). He lists 31 species with

1 This is a copy of the dissertation submitted to the Graduate School of the University of Cincinnati in partial fulfillment of the requirements of the degree of Ph. D. (June, 1939).

comments on habitats and describes several new species of ostracods from this area. The seasons embraced by the study are not specified but the context implies collection in late spring, summer, and early autumn.

The present work was undertaken to analyze the local Entomostraca as to species and numbers at all seasons of the year with the further aim of interpretation from an ecological standpoint. The lack of such seasonal studies in most regions, including Cincinnati, makes a problem of this type worth while both as a contribution to the general field of plankton investigations and as a body of information with intrinsic interest. Virtually all previous serial observations have been lacustrine, and year-round conditions are almost undescribed in such small ponds and pools as were chosen for this work. Although a local species list is provided, its importance is regarded as secondary to the broader problem of seasonal fluctuations and environmental relations. Records of the more important physical, chemical, and biotic conditions were made with each collection and studied as correlative factors in the annual cycle. Special emphasis on frequent collection at all times of the year was necessary to secure a complete picture of the entire population. Consequently the chief study has been consecutive observations of a small number of collecting places with the belief that detailed information on a few representative communities throughout the year is of greater value than many scattered investigations without reference to season.

It is a pleasure to thank Dr. William A. Dreyer for his interest and helpful advice during all phases of the problem. Dr. William A. Spoor has also given encouragement and counsel on many occasions. I greatly appreciate the help given by Dr. Norma C. Furtos in the identification of several ostracods. I am indebted to Lawrence Hobson, Bertrand Kriete, Marguerite H. Overholt, and several others for frequent assistance on field trips. I appreciate the courtesy of Dr. Charles Goosmann, of C. H. Rouster, and of the authorities of Arlington Memorial Park in allowing weekly collections from ponds on their properties. John A. Bledsoe has kindly given professional help in the preparation of photographs.

Collecting Sites

The stations from which regular weekly collections were made from October, 1937, to October, 1938, were four in number. Stations 1 and 3 were also sampled in spring, 1937. With the exception of 4 A, which was drained in October, 1938, all stations were visited monthly from October, 1938, to April, 1939. Thus, records for stations 1 and 3 extend over a two year period, those for stations 2 and 4 B extend over eighteen months, and those for station 4 A over a single year. Single collections were made from 20 other places at various times from March, 1937, to September, 1939. These spots varied greatly in size, age, and nature, and were visited chiefly for comparison of their fauna with that of the regular stations to ascertain whether or not the weekly collections were of representative character.

Station 1.—This site consists of a group of small woodland ponds near Goshen, Ohio (Fig. 1). The pools were made at least 20 years ago and are situated in an oak-hickory forest. The three ponds form a very close group, no two of them being more than fifteen feet apart. 1 A is the deepest of the three, being 18 inches at the center, and is connected during the high water

of spring and early summer with the shallower and larger pond 1 B. While A and B were thus in communication samples were taken only from B in the spring of 1938 and from both ponds in spring, 1939. I C is a natural temporary pool, first found to contain water in both 1938 and 1939 on February 3. It became dry and refilled several times in spring and summer, 1938. The intermittent character of this pool of course limits its fauna to forms which can survive a period of drying and thus allows the appearance of types such as the fairy shrimp, which require desiccation at one phase in their history. A lining of leaves maintains the clarity of the water in 1 C, but the soft clay bottom of the other two ponds usually causes considerable turbidity. Higher plants seem lacking in ponds A and C and are represented in B only by a few clumps of pond-weeds.

Station 2.—This pond, measuring 90 x 280 x 4½ feet in greatest dimensions, was formed about 30 years ago by the damming of a small stream (Fig. 1). The water is stagnant for the greater part of the year, although in spring and early summer there is some flow from a rivulet at the upper end and compensatory drainage over the dam. In summer cat-tails *(Typha)* border the sides of the pond, pickerel weed *(Pontederia)* is prominent, the hornwort *Ceratophyllum* is thick, and a duck-weed, *Lemna minor*, blankets the edges.

Station 3.—This 70 year old pond measures roughly 500 x 125 x 10 feet, although the depth in the inlet where collections were made was less than 4 feet. A slight circulation is maintained for most of the year but disturbs the water in the inlet so little that a dense blanket of duck-weed covers it completely in summer (Fig. 2-D). The dense vegetation includes, in addition to the duck-weed *Spirodela polyrhiza*, *Sagittaria*, much *Ceratophyllum*, *Typha*, and other plants in lesser amount. *Spirogyra*, other filamentous algae *(Desmidium)*, and several kinds of very small desmids are abundant at times. Turbidity is usually so slight that the soft mud bottom and the submerged vegetation are visible in 5 or 6 feet of water.

Station 4.—These collecting sites are artificial bodies of water formed for the raising of goldfish. 4 A, 8 years old, is a ditch 63 x 16 x 2 feet with a muck bottom. In summer it is choked with *Elodea* and contains pond-lilies. *Castalia*, and *Sagittaria* (Fig. 2-A). It was drained October 1, 1938, and was first found refilled on April 10, 1939. 4 B, 4 years old, is a sheep pasture pond 99 x 50 x 4 feet in dimensions. It was once stocked with a net full of *Daphnia* from another pool on the farm. In late summer the pond develops a few water hyacinths *(Eichhornia)*, some *Sagittaria*, and an occasional clump of *Cladophora*, but in general presents a very bare appearance (Fig. 2-B). The water is usually turbid and very green because of myriads of minute green flagellates. The normal seasonal picture was somewhat distorted at this pond by the introduction of a number of tropical fish in early summer and by a dry period from October 1, 1938, to November 30, 1938. Although objections may be raised to the inclusion of two such recent artificial situations as ponds 4 A and B in a study of this kind, they do serve to show the contrast between a natural population and the biota of a semi-controlled environment and since the organisms introduced are common local species, their use seems justifiable.

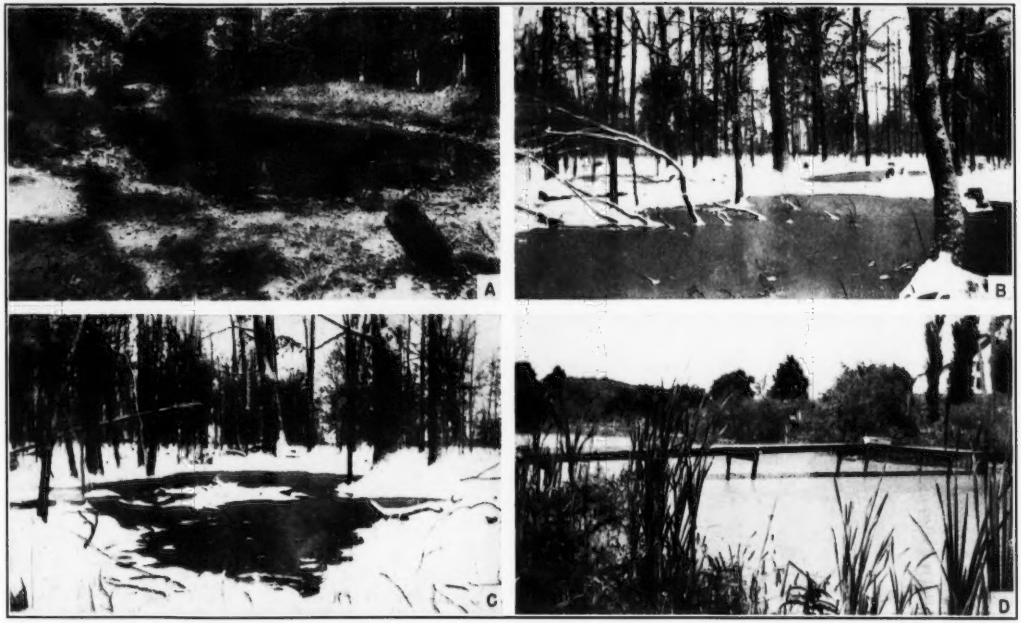

Fig. 1. Collecting Sites at Various Seasons. A—Station 1, pond A. September 28, 1938. B—Station 1. Pond B in the foreground; pond A in the right background; pond C in the left background. February 3, 1939. C—Station 1, pond C, a natural temporary pool. February 3, 1939. D—Station 2. June 29, 1938.

D—Station 2. June 29, 1938.

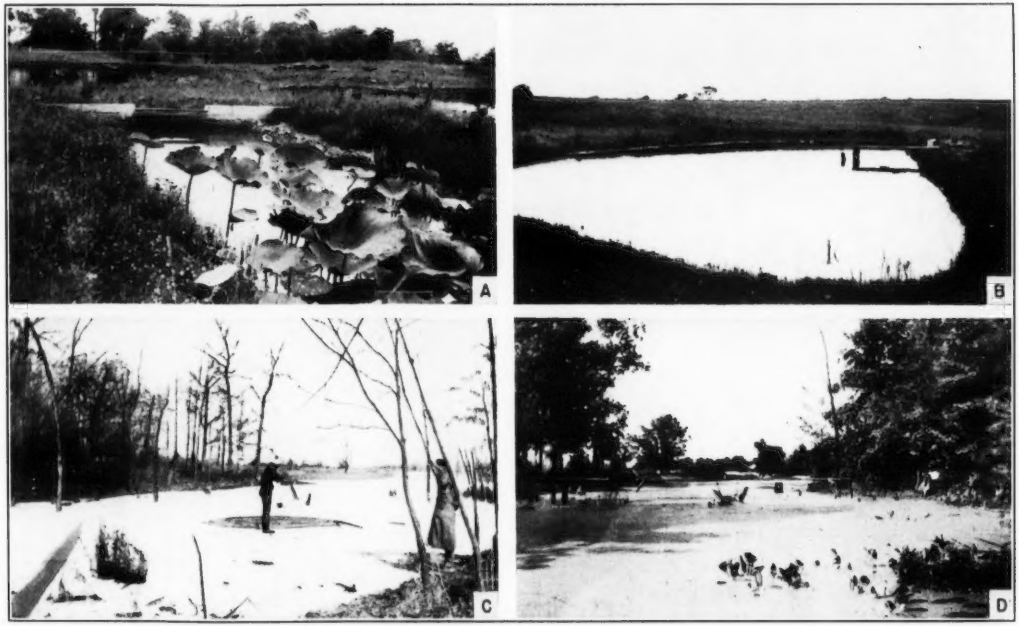

Fig. 2. Collecting Sites at Various Seasons. A—Station 4A. July 2, 1938. B—Station 4B. July 2, 1938. C—Station 3. January 16, 1938. D—Station 3. June 27, 1938. Note the dense blanket of duck-weed.

Methods

Physical and Chemical Factors.—The following observations were made at each station each week (with 8 exceptions which were not consecutive) from October, 1937, to October, 1938. From then until April, 1939, monthly determinations were made at each station. In each case the time of observation of these factors coincided with that of collection of material.

1. Dissolved oxygen content. This was determined by the Winkler method. Bottles were filled 6-8 inches below the surface.

2. Carbon dioxide. Free CO_2 bicarbonates, and carbonates were determined by the Seyler method. Bottles were filled 6-8 inches below the surface.

3. Hydrogen ion concentration. The colorimetric method, giving the measurements in terms of pH, was used for this determination. The tubes were filled 6-8 inches below the surface of the water and the readings were made in the field.

4. Temperature. Air and water temperatures were taken with an ordinary Centigrade thermometer. Air temperatures were read at a height of about three feet from the ground and a few yards from the pond. Water temperatures were taken with the thermometer submerged to a depth of 8-10 inches, which caused it to rest on the bottom of several of the shallower ponds.

5. Turbidity. This was estimated by a modified Secchi disk. A white enamel button 3.5 cm. in diameter and mounted on a wooden block was lowered into the water until the disk disappeared and the extent of the submersion was noted in inches. This gave figures with some relative significance but obviously with no absolute value. Relative results were probably affected to some extent by the amount of light, which varied with time of day and year and with sky conditions.

Also noted as part of the physical environment on each trip were the time of day, the condition of the sky — i.e., cloudy or sunny, the falling of rain or snow, the relative amount of water at the station (high, low, or average), and the condition and thickness of the winter ice cover. Prominent biotic features, both plant and animal, were noted and recorded with each collection in addition to observation of the Entomostraca present.

Collection.—A standard method was evolved for the weekly collections and adhered to throughout the work. The single collections made from other stations were primarily qualitative and consequently material was gathered by many random net sweeps rather than by a constant number. At the regular stations the net was drawn through the water while submerged to a depth of 6 to 8 inches in a series of 2 yard sweeps. The number of sweeps composing a collection was reduced from 20 to 10 on November 20, 1937, when it was found that the smaller number gave representative and less bulky collections. The counts were corrected to correspond in all samples to the number of organisms in one two-yard sweep of the net, a quantity which is designated as a collecting unit.

The net used was made of fine batiste according to the pattern recommended by Birge (1918) for plankton collecting. The material, as measured under the microscope with a calibrated ocular micrometer, possessed approximately 1700 meshes per square centimeter. The openings in new washed material averaged 0.0158 sq. mm. in size, while the average for material after nine months of use was 0.0163 sq. mm. The slight change in size of openings with use probably does not materially affect the amount of the catch. No adult and few, if any, young Entomostraca are small enough to pass through the net openings, even nauplii being too large for escape. The net was washed frequently in hot water and soap to prevent clogging, and slight rents were promptly repaired. The net, reinforced at the top with several layers of unbleached muslin, was sewn to a wire frame enclosing an area of 452.39 sq. cm. The net was conical 58.5 cm. long and tapering to a lower diameter of 6.5 cm. The lower end was left open and provided with a tape for tying. Each collection was washed from the net into a liter of water from the pond from which it was taken. Upon return to the laboratory each bucket was thoroughly shaken and 200 cc. of the contents poured off into a container to which 20 cc. of formalin were added. These samples were used for differential counts of Entomostraca. The remainder of each collection was carefully examined in the fresh condition, and it was from this material in most cases that initial identifications were made.

In all, 320 consecutive collections were made, examined, and counted. Supplementary single samples were taken from 20 other locations and the species identified.

Although many methods have been devised for estimating net coefficients none is completely satisfactory. The following estimates, using the same net employed in the Cincinnati collecting, were made at Lake George, Indiana, during summer, 1939. The rather uniform nocturnal distribution of plankton in the upper waters made the situation especially suitable for such methods. For each determination careful counts were made of the catch of one two-yard sweep compared to that resulting from filtering the volume of water (84 liters) theoretically drawn through the net by such a sweep. An average of twelve such determinations gave the coefficient 2.31 — i.e., the number of organisms in one collecting unit must be multiplied by 2.31 to give the number in 84 liters. Clogging during the haul also affects the amount of the catch, necessitating a further factor which was obtained by finding the ratio of numbers in one sweep to the total catch of ten sweeps. Although the degree of clogging must vary greatly with the amount of suspended material, figures for Lake George probably represent a fair average, as the number of organisms present was intermediate between the extremes at regular stations. It was found that one-tenth of a ten-sweep catch must be multiplied by 1.69 (average of 8 determinations) to equal the number of organisms obtained in a single sweep with a clean net. Combining both factors gives a coefficient of 3.90, indicating a net efficiency of slightly more than 25%. Thus one two-yard sweep theoretically yields the organisms contained in 21.5 liters of water. It is possible that under special conditions the amount filtered might be reduced or increased by several liters. In order to make the maximum allowance for

such discrepancies it should suffice to regard a collecting unit (one two-yard sweep) as representing the number of organisms in approximately 20 liters of water under ordinary conditions with the possibility of variations from 15-25 liters in unusual circumstances.

It is realized that this method of sampling does not result in quantitative accuracy, such as that attained by volumetric plankton pumps and other devices now used in lacustrine collecting. Such apparatus is utterly unsuited to collection from the extremely shallow, mud-bottomed, and frequently weed-choked ponds of this study. The only other feasible method would have been the pouring of measured quantities of water through a net. Since such a procedure, to secure samples as adequate as those of the sweep method, would have required the filtration of approximately 200 liters of water from each station weekly it was ill-suited to the purpose. Aside from the tedium of such a task repeated filling of a large vessel would frequently have stirred sediment enough to fill the samples with mud, there were many places where it would have been virtually impossible to collect 200 liters of water free of debris, and during the winter months the net would have frozen long before the pouring process was finished. The method adopted seemed the only adequate means of coping with the problem, and since collecting units almost certainly did not filter less than 15 liters nor more than 25 liters of water, fluctuations of 100% or more in total numbers of organisms are of significance. If numerical changes of this or greater magnitude and relative proportions of the various Entomostraca in all samples are regarded as representing actual conditions while smaller total fluctuations are neglected, the seasonal changes in the population can be acceptably traced.

Counting.—Each sample was prepared for counting by draining off the fluid through cloth identical with the net material, suspending the catch in 50 cc. of water and distributing it evenly by agitation in a Petri dish 950 mm. in diameter. Counting all organisms in one-fourth of this area (when the haul was 40 yards) or one half of this area (when the haul was 20 yards) represented the actual number in a collecting unit.

Counting disks were prepared by ruling off sufficient squares, 1 cm. on a side and provided with a 2 mm. strip the length of one side, to make up one-fourth the area of the dish. In many cases, dilution was imperative before counts could be attempted. This dilution was varied in accordance with the amount of the catch but was always kept as low as possible. The most extensive amount was $^1/_{20}$, which was necessary several times, particularly on collections from Station 4 B, where the counts frequently ran up to ten or even twenty thousand Entomostraca per collecting unit. Counts were made under a Zeiss binocular microscope at a magnification of 10x. In cases where dissection or higher power was required for identification, examination under the compound microscope was always made. Since this could not be done with each individual, a definite number of those in question was examined and the ratio of the different species recorded. Thus, the counts probably more nearly represent the true ratios for Cladocera, many of which can readily be distinguished under the binocular, than they do for Copepoda and Ostracoda, of

which many require higher power. These weekly counts of each species of entomostracan at each station are recorded in tabular form in the original thesis in the University of Cincinnati library. The tables are not included in the present paper, nor will any attempt be made here to describe numerical details of the annual cycle for each species, as these data belong more properly in a separate article. Wherever reference is made to number of Entomostraca present, this is expressed in terms of number per collecting unit (the number in approximately 20 liters of water at the station under discussion).

The total number of Entomostraca occurring each week and the number of Phyllopoda, Cladocera, Copepoda, and Ostracoda are expressed graphically (except 1 A) for a one-year period from October, 1937, to October, 1938 (Figs. 3-7 and 9). The numbers are expressed per collecting unit and are graphed logarithmically. From a practical standpoint logarithmic expression was necessary in order to reduce the graphs to workable size, as it is impossible to express with actual values numbers varying from 16 to 41,756, for example, within the limits of an ordinary page. The logarithmic expression does not seem objectionable on theoretical grounds, as increases in number where the total is small are shown equally as well as the changes where the total is large. If one adopts the premise that a doubling in number, whether from 10 to 20 or from 10,000 to 20,000 is always equally significant, a logarithmic graph presents results in perfect perspective.

Results

I. Physical and Chemical Factors

These factors as observed at each station each week are presented in tabular form in the appendix, and only the most general features will be discussed.

The importance of turbidity as an influential factor appears to depend chiefly upon the nature of the suspended material. At station 1 this was mostly inorganic matter from the clay bottom. The significance of such material except as protection from direct sunlight is probably slight. In summer cattle visited this station freqently and increased not only the actual turbidity but also its organic content (protozoans, bacteria, etc.). Turbidity was great at ponds A and B of station 1 until late summer, 1938, when the amount was greatly reduced and remained so during the rest of the study. I C was very clear throughout all observations, showing imperceptible turbidity. At station 2 turbidity was caused chiefly by the stirring of bottom sediment and the introduction of silt when the small brook at the upper end was flowing; hence it was usually highest in spring and after heavy rain in summer. Measurable turbidity at station 3 was rare at the depth where collections were made, the water usually being so clear that details of the bottom were plainly visible. At 4 A turbidity variations were wide and depended chiefly upon stirring of the mud bottom by heavy rain. Turbidity at 4 B was often extreme and was due at times to inorganic matter from the bare bottom and at times to the accumulations of flagellates and desmids which were frequently so numerous in this pond.

The amount of dissolved oxygen in the water varied greatly from station to station and with the seasons at each situation. Particularly in pools with

little vegetation highest values were recorded in winter when the low temperatures increased the oxygen solubility in water. No measurable oxygen was found at station 1, A and B, on November 24, 1937, the date on which ice first appeared. It is interesting that even in this apparently oxygenless water some living Entomostraca and dipterous larvae (*Chaoborus* sp.) were present. On several other occasions values were very low, as at 1 A on December 1, 1937 (0.86 cc. per liter) and on June 15, 1938 (0.68 cc. per liter). Oxygen content at station 2 only once fell extremely low (0.67 cc. per liter on Sept. 15, 1938) and usually showed a level somewhat higher than those of the pools of station 1. Oxygen content never fell so low at stations 3 or 4 as at 1 and 2, partly because of the great abundance of aquatic plants. Values above 10 cc. per liter for nine consecutive weeks in the spring of 1938 at station 3 are interpretable partly as due to the annual pulse in algae, chiefly *Spirogyra, Desmidium, Micrasterias, Pleurotaenium,* and the green flagellate *Volvox.* The high summer oxygen values at this station probably were also of plant origin, as *Cosmarium, Closterium, Ceratophyllum,* and *Spirodela* then abounded. Fig. 8 shows the annual oxygen cycle at station 4 A, where high winter values are referable to increased solubility and a fairly high summer level to the dense growth of *Elodea.* Oxygen content is of special interest at station 4 B because of the very large amounts frequently present (up to 25 cc. per liter). This supersaturation was associated with the presence of myriads of the small green flagellate *Cryptoglena,* these being so numerous at times that water from the pond was dull grass green. In November, 1937, and July, 1938, the two occasions of greatest oxygen concentration, the effect of the flagellates was augmented by the presence of many *Scenedesmus.* The fact that Shelford (1918) reports a maximum concentration of oxygen in natural fish waters of 24 cc. per liter together with the reports of various investigators of supersaturations amounting to 200-300% under special conditions indicates that the values obtained here are not unprecedented.

A general account of carbon dioxide relationships is difficult, as these varied greatly with the character of the station. Station 1 as a whole and particularly the temporary pool 1 C showed the usual condition of acid, soft water ponds where the free carbon dioxide is high and carbonates are low. At station 2 carbon dioxide in the free state was usually moderate in amount while carbonates were consistently rather high. In spite of the usual acidity of the water at station 3, the free carbon dioxide there was always rather low. The release of organic acids by the decay of living matter may have been partly responsible for the acid reaction, as the extensive biota would suggest. Carbonates were high in the autumn of both years and extremely low in the spring and early summer. Carbonates were also high in the autumn at station 4 A with free carbon dioxide medium in amount. The condition at station 4 B is interesting in view of the fact that free carbon dioxide in small quantities is usually regarded (Shelford, 1918, and Welch, 1935) as essential for aquatic animals. Although it has been said that "the greater the supply of available carbon dioxide, within limits, the greater the potential productivity, other circumstances being the same" (Welch, 1935), 4 B, the most productive pond of this series in numbers of Entomostraca and flagellates often failed to

show any free carbon dioxide for weeks at a time. Its consumption by the numerous chlorophyll-bearers of this pond must have been partly responsible. This is corroborated by the fact that highest oxygen values roughly correspond with periods of greatest alkalinity, when the flagellates and desmids were most prevalent. Bound carbonates ran high, as expected in the absence of free carbon dioxide, while bicarbonates were frequently small in amount.

The pools of station 1, showing a variation from pH 5.5-6.8, all exhibited a lower average pH than any other stations. This acidity was especially pronounced at the small temporary pond 1 C. During the greater part of the observation period at station 2 the pH was remarkably constant but showed a summer tendency toward alkalinity on three occasions, which extended the range from a low of 6.8 to a high of 8.7. There were frequent periods of several months, however, when pH readings were never more than half a unit apart at this station, with pH 7.0 the commonest figure. The pH at station 3 varied widely, from 5.5-9.5, but the alkaline values were exceptional and occurred chiefly in the summer; 60% of the determinations lay between pH 6 and pH 7. A year's pH cycle at station 4 A is presented graphically in Fig. 8. Readings varied from 6.1-8.4 with remarkably constant values from October, 1937, to March, 1938, and small fluctuations from then until termination of the observations. The very high pH values recorded at station 4 B on many occasions are unusual. Fluctuations were irregular but often fairly extensive, carrying the pH at one reading down to 7.0, while at the other extreme six observations were above the highest available indicators (9.6). Responsibility for this alkalinity was not fixed; carbonates alone appeared insufficiently high to be producing the reaction.

Temperature was the greatest variable at all stations. In such small bodies of water, where thermoclines and overturns did not occur, the water temperature closely paralleled that of the air, thus subjecting the contained organisms to great extremes of heat and cold and to rapid temperature fluctuations. These conditions were of special importance at the very small stations such as 1 and 4 A, where the water was so shallow that practically no refuge was afforded from extremes of heat and cold even at the bottom. Weekly temperatures for a one-year period at station 4 A are graphed in Fig. 8; fluctuations at the surface were quite similar at other stations, though in the deeper ponds bottom temperatures were frequently more moderate. Variations from 0° to 29° C. in the temperature of the surface waters were recorded in the annual cycle, the differences between stations in the extremes attained being very slight.

Evidence as to the importance of these physical and chemical factors in determining quantitative and qualitative aspects of entomostracan distribution at the various stations is presented in the discussion.

II. Biotic Analysis by Stations

Station 1 A.—The biota other than Entomostraca was very rich and can be treated only briefly. Protozoa occurred in all collections, with a spring and summer prominence of stalked ciliates and of flagellates and the presence in winter of shelled rhizopods. Simple plants occurred in small numbers, espe-

cially in spring and summer when several species of desmids and other algae, as *Pleurotaenium, Zygnema,* etc. were regularly taken. This station was less rich in this respect than 1 B. *Chlorohydra viridissima* was found in spring and fall in very small numbers, and although they were obviously feeding on Entomostraca, the effects could not have been of great magnitude. Small free-living nematodes were frequent in winter, and in fall and early winter rotifers were common. *Stylaria* and *Tubifex* were common oligochaetes, the latter occurring in enormous numbers in June and July. Odonata nymphs were frequent, larval and adult Coleoptera appeared often, several Hemiptera were regular inhabitants, and larvae of Diptera were very prominent. Of the latter, *Chaoborus* was found in great numbers throughout the year, often as many as 200 per collecting unit. That these predacious larvae materially affect the entomostracan fauna can scarcely be doubted from a study of their food. All orders of Entomostraca, but especially Ostracoda were frequently observed in their alimentary canals. In late May and June *Chaoborus* pupae were common and imagoes began to appear; from then until July the larvae present were nearly all of the young, newly hatched generation. By late July or August many of these were of full larval size, but newly hatched individuals continued to appear until September. Molluscs were never common but an occasional *Limnaea* or *Ancylus* was taken.

The amphibian population was the most important spring factor in limiting entomostracan numbers. For several months, beginning in February, all ponds at station 1 contained numerous *Ambystoma* larvae, first those of *Ambystoma opacum,* followed at A and B by those of *A. jeffersonianum* and *A. maculatum.* These larvae use Entomostraca as one of their chief foods, and adults were found to be eating some also, especially Ostracoda. Frog tadpoles are prominent at stations A and B except in midwinter, and these were found to be consuming ostracods to some extent.

The following species of Entomostraca were taken at 1 A during the period of collection: Cladocera — *Alona rectangula, Chydorus sphaericus, Daphnia pulex, Leydigia quadrangularis, Pleuroxus denticulatus, Pleuroxus hamulatus, Scapholeberis mucronata,* and *Simocephalus exspinosus;* Copepoda — *Canthocamptus staphylinoides, Canthocamptus staphylinus, Cyclops albidus, Cyclops prasinus, Cyclops serrulatus,* and *Cyclops viridis;* Ostracoda — *Candona crogmaniana, Candona ohioensis, Cypria elegantula,* and *Cypridopsis vidua.* None was exclusively found here although *Alona rectangula* and *Candona ohioensis* were found only at station 1. The seasonal peculiarities of the distribution of the various groups were not graphed for 1 A because of the fact that when A and B were continuous in the spring of 1938 collection was made only from 1 B.

Seasonal distribution of each species is not discussed for each station separately but will be found in the general results. Only conditions peculiar to one locality are treated under that heading. Such a set of circumstances is involved in the seasonal history of *Simocephalus exspinosus.* This large member of the family Daphnidae is said by Birge (1918) to be "not common; reported from Massachusetts, Wisconsin, and the southern states" and yet it

occurred in considerable numbers at various times at station 1. It was also found in an old canal bed near Cincinnati on May 21, 1937. The distribution should certainly be extended to include Ohio, as Roach (1932) has found it also in his studies of the Hocking River, where it was a member of the autumn plankton. It was first found at station 1 on April 9, 1937, and again on May 28, 1937, occurring in both A and B. Early autumn samples of the same year did not reveal it at either pond, its ecological niche apparently being occupied by *Daphnia pulex*. *Daphnia* was last found at 1 A on November 3, and the next week showed over 200 *Simocephalus exspinosus* per unit. Similar observations were made at 1 B, where, however, *Daphnia* disappeared two weeks earlier, and *Simocephalus* was first present on October 20. The latter persisted in 1937 until early in December and was not found again until autumn of 1938. *Daphnia* reappeared in March, 1938, and was the dominant cladoceran at both ponds until September 8, when its place was again abruptly taken by *Simocephalus exspinosus* at 1 B. This, as in the previous year, was followed by the same behavior at 1 A somewhat later (November 11). During 1937 *Simocephalus* was found in spring and fall but during 1938 the spring appearance was entirely absent and it was present only in autumn. In the winter of 1938-39 it was constantly present, and it was still persistent at the last observation on April 25, 1939. These data suggest the possibility of a biennial cycle for *Simocephalus exspinosus* somewhat similar to that described by Birge (1898) for *Daphnia pulex pulicaria* in Lake Mendota. On the other hand, the cyclic phenomenon may be that of *Daphnia*, which appeared in spring only in 1938, an appearance which may have prevented the development of *Simocephalus* at that time. The point cannot be settled, but one argument in favor of *Simocephalus exspinosus* as possessor of the rhythm is the lack of such a cycle in *Daphnia pulex* at station 4 B. This also prevents the simple assumption that *Daphnia* is less tolerant of low temperatures than *Simocephalus*, as *Daphnia* was taken in great numbers from 4 B in mid-winter. The similarities in size and general behavior of these two species may make them competitors which cannot exist simultaneously in the same small pond. What circumstances cause the ascendancy of one species at one time and of the other at another cannot be stated with finality on the basis of present records. A somewhat similar set of conditions is described by Pacaud (1939), who observed a clear unpolluted pond containing *Simocephalus vetulus*. When sewage was introduced *S. vetulus* disappeared and as pollution advanced *D. pulex* became the dominant cladoceran. The appearances of *S. exspinosus* at station 1 correspond roughly with periods of least pollution, while *Daphnia* was the dominant form during the warm months of 1937-1938 when cattle were visiting the ponds and polluting them with excrement.

The absence of the fairy shrimp, *Eubranchipus vernalis*, from the records of this station is due to the lack of collection from 1 A during its period of abundance. It occurred in this pond in very small numbers during the time it was confluent with 1 B, from which the samples were then being drawn.

Numerical results at this pond were similar in general to those for 1 B and reference to the graph (Fig. 3) of the latter will give the seasonal picture fairly well. The early fall rise was due to *Simocephalus exspinosus*, and the rather

high winter population was mainly *Cypria elegantula,* with a peak of *Canthocamptus staphylinoides* on December 22. The reproductive period of *Cypria* in April and May caused the numbers to rise, due to the many larval ostracods. After a slight reduction in total population with the falling off of *Cypria, Daphnia* became the dominant form and increased to give the yearly peak at this station on July 20 (total of 14,900 Entomostraca). Summer levels were increased also by another of the Daphnidae, *Scapholeberis mucronata.* Beginning in August, totals fell gradually until mid-September and then dropped abruptly to the autumn level. This was not so low as in autumn of 1937 due to the somewhat later persistence of *Daphnia pulex.* Winter and spring levels would not be very different if it were not for the earlier onset of reproduction of *Cypria* in 1938-1939, which brought somewhat higher totals the second year. Copepods were never responsible for pulsations in the population at this station, occupying a position of medium importance, except for occasional fluctuations, throughout the year. Canthocamptids swelled the winter and early spring numbers, while young *Cyclops* were important in March and again in July. Ostracods other than *Cypria elegantula* had virtually no effect on total counts, occurring only in small numbers. Further treatment of numerical data will be found in the discussion.

Station 1 B.—Biotic features here were very similar to those at A. In addition to the forms mentioned there, a bryozoan, *Plumatella princeps,* was very common in summer and fall and *Gyrinus* was often seen. The same algae, such as *Stauroneis, Pleurotaenium, Netrium, Closterium, Spirogyra,* and *Zygnema* were found at both ponds, but the supply was more plentiful at B. If algae are the chief food of Entomostraca, it seems that B should have been more productive of entromostracans than A. However, accurate algal counts might reveal that this difference in plant life between A and B is more apparent than actual. Also, as Birge has shown, various Entomostraca are extremely selective as to algae consumed, and it may be that the more numerous types at B are not an important source of food. The Crustacea of these ponds may be feeding on fine organic matter in suspension to the exclusion of algae, as examination of stomach contents failed to reveal recognizable plant remains. This is not incompatible with the work of Huff (1923) who found that destruction of algae at Vadnais Lake on several occasions did not materially affect the number of Entomostraca and who states that the decay of higher seed plants, etc. of a lake or pond contributed more largely to the food of Crustacea than do the algae.

The following Entomostraca were taken at station 1 B during the period of observation: Phyllopoda — *Eubranchipus vernalis;* Cladocera — *Alona costata, Alona rectangula, Chydorus sphaericus, Daphnia pulex, Leydigia quadrangularis, Pleuroxus denticulatus, Scapholeberis mucronata,* and *Simocephalus exspinosus;* Copepoda — *Canthocamptus staphylinoides, Canthocamptus staphylinus, Cyclops albidus, Cyclops bicuspidatus, Cyclops fuscus, Cyclops prasinus, Cyclops serrulatus,* and *Cyclops viridis;* Ostracoda — *Candona crogmaniana, Candona ohioensis, Cypria elegantula, Cypridopsis vidua,* and the larvae of a species of *Eucypris.*

Several of these forms were never found at A. *Alona costata* is a common species everywhere, actually much commoner in this series of stations than *Alona rectangula*, which was found only at station 1; hence its presence is not extraordinary, although it is rather odd that it was not taken at A. *Cyclops bicuspidatus* may be assumed to have occurred at A as well as at B during the time it was confluent with A, and the same is true of *Cyclops fuscus*. Probably it is only because A was not sampled during the time of prevalence of these forms that they do not appear in the records there. *Eubranchipus vernalis* and young *Eucypris* sp. fall into the same category and almost certainly occurred in both ponds, although the infrequent spring records of 1937 and 1939 do not reveal them. The changes in water level of A and B probably give them a sufficiently temporary character to allow development of the fairy shrimp eggs. Although migration of the animals after hatching from the temporary pond C to B, where they were found, was possible through several small channels, the shrimps at B probably hatched at that pond. This is suggested by the fact that they attained maturity considerably earlier than those in C, were consequently larger and more advanced in development at any given week, and were always quite different in color.

Graphic presentation of the numbers of Entomostraca by major groups for a one-year period is made in Fig. 3. A rather low level existed in October and November, with *Simocephalus exspinosus* determining the general shape of the curves, and with small October rises in *Cypria* and in *Cyclops serrulatus*. With the disappearance of *Simocephalus*, the totals for several succeeding months were chiefly determined by the numbers of *Cypria elegantula*. Four peaks, in December, February, March, and April, were formed chiefly of *Cypria* with *Canthocamptus staphylinoides* making definite contributions. The spring maximum, on May 4, of 2240 Entomostraca per collecting unit, was composed chiefly of young *Cypria*, with some contribution by *Daphnia pulex*, while the copepods were unimportant. With the high temperatures of late May, *Cypria*, being predominantly a cool water form, lost its position and finally ceased to appear in late June. In the meantime *Daphnia* was on the increase and determined the totals for June, July, and August. Some influence on the general level was exerted by young forms of *Cyclops*, probably chiefly *albidus* and *viridis*. The yearly maximum fell on July 13 (for the 1937-1938 period) with a total of 6456 Entomostraca, of which 6408 were *Daphnia pulex*, nearly all young individuals. A second pulse of 4592, again due to *Daphnia*, was observed on August 9. The fall in numbers, occurring in late August when temperatures were still high, involved all groups. This was followed by a rise induced chiefly by *Simocephalus exspinosus*, with contributions by *Cypria* and by *Cyclops*, a general picture somewhat similar to that occurring the previous year a few weeks later. The situation the following year, while not graphed and observed only at monthly intervals, revealed numbers of the same general level. Several counts are strikingly similar, for instance the total of 54 on November 10, 1937, and that of 52 on November 11, 1938, with the composing species being practically identical. In most cases, however, the correlation is far from close. This is due in part to the erratic behavior of *Cypria elegantula* and in part to the persistence of *Simocephalus exspinosus* in the winter of

1938, which was discussed above. Quite a different seasonal picture would certainly exist at this station if the dominant ostracod were not *Cypria elegantula*. Otherwise the winter numbers would have been extremely few, as these small ponds with their extremes of temperature appear able to support only very cold-hardy forms in any considerable number in winter. The fact that this condition of ostracod dominance is unusual will be more evident after consideration of the populations of the other stations.

Station 1 C.—The general biotic picture here is typical of natural temporary woodland pools and will be presented with great brevity. Some of the algae observed at A and B were found in the late spring and summer in small amounts, as was also *Oedogonium*. Protozoa were present at all times, several species of flatworms were common, leeches were abundant, *Chaoborus* larvae were few, the larvae and pupae of *Culex* were present in enormous numbers as summer approached, the isopod *Asellus communis* was prominent, and the small clam *Sphaerium* was often taken. From the first appearance of water in February, numerous larvae of *Ambystoma opacum* were present and feeding on Entomostraca.

The following species were taken at 1 C during the period of study: Phyllopoda — *Eubranchipus vernalis;* Cladocera — *Alona costata, Chydorus sphaericus, Daphnia pulex, Scapholeberis mucronata,* and *Simocephalus exspinosus;* Copepoda — *Canthocamptus northumbricus, Canthocamptus staphylinoides, Canthocamptus staphylinus, Cyclops bicuspidatus, Cyclops prasinus, Cyclops ater, Cyclops phaleratus, Cyclops serrulatus, Cyclops viridis, Diapto-*

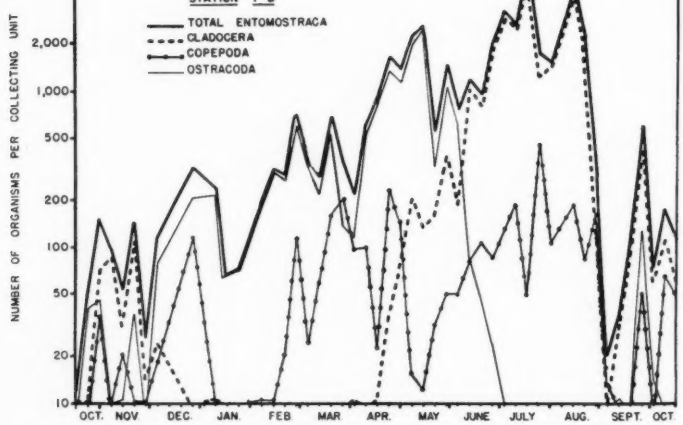

Fig. 3. Station 1B. Seasonal census of Entomostraca by major groups, Oct., 1937-Oct., 1938.

mus sanguineus, and *Osphranticum labronectum*; and Ostracoda — *Candona crogmaniana, Cypria elegantula, Eucypris fuscata* and two *Eucypris* species of which descriptions have not yet been published. Dr. Furtos (personal communication) has taken one of these, a small green form, from ponds near Cleveland in April and has described it but not in publication. A form quite similar to *Eucypris fuscata* but differing in color and some other features was found in small numbers in association with *E. fuscata*. This is a species somewhat similar to a new form observed by Furtos in the same type of environment near Cleveland, but is not identical.

Canthocamptus northumbricus, Diaptomus sanguineus, Osphranticum labronectum, and the three eucyprids were peculiar to this pond. Larval *Eucypris* was observed at several other spots in spring, but only at C did they mature and occur in considerable number. With the exception of the canthocamptids the presence of the exclusives is almost certainly due to the fact that only at C is found the period of drying essential to completion of their life histories. *Canthocamptus northumbricus* is not described as peculiar to temporary ponds, and it is possible that its absence from other stations is an accident of distribution rather than a significant condition. On the other hand the data on life histories of these forms is rather scanty, and the fact that *C. northumbricus* has a tendency to occupy temporary ponds may have escaped previous observation or publication. In addition to the exclusives at C, several species of rare occurrence in this study were also taken. *Canthocamptus staphylinus*, never common, was found here twice in some numbers. *Cyclops ater* was so rare as never to figure in the counts and was taken at C only once, in February, during the period of weekly observations. It was found there again in spring, 1939, and was recorded there for April, 1937. Station 3 was the only other place of its occurrence, and it was found there only on November 30, 1938. This autumn appearance agrees with the observations of Roach (1932) as to its seasonal distribution in the Hocking River. The fact that Turner (1892) took it shows that it also occurs in this area in the warmer parts of the year, as his collecting appears to have been confined to late spring, summer, and very early fall. *Cyclops phaleratus*, likewise exceedingly uncommon, was found in very small numbers in April, 1938, at C. So few were present that none was ever included in the counting samples but the fresh material revealed them. This appearance was not repeated in 1939, but it was observed on one occasion, November 3, 1938, at station 3.

The considerable number of exclusive or uncommon species at C, while chiefly due to its temporary character, may be in part due to its long existence. It appears to be a natural depression which probably has contained water annually for many years. *Cyclops ater* and *C. phaleratus* were found here and at station 3, the pond of greatest known age in the study.

Numerical results are graphed logarithmically in Fig. 4. The general shape of the curve during the first period when water was present was determined by the canthocamptids, chiefly *Canthocamptus staplylinoides*. *Eubranchipus vernalis* was present in rather large numbers, but as the size increased, the number per counting unit inevitably fell off. The ostracods, which con-

tributed somewhat to the peak of April, were chiefly larvae of *Eucypris*, mainly those of *E. fuscata*. Also contributing considerably to the yearly high on April 21 was *Daphnia pulex*, which increased gradually in number from February 10 until that time. The May drought was followed by the appearance of organisms in about the same total number as that following the appearance of water on February 3. Here, however, with the warm temperature, *Canthocamptus* was not the important copepod, the early peak being caused by young *Cyclops*, chiefly *C. viridis* and *C. serrulatus*. This copepod lead was quickly replaced by a cladoceran peak, due to a period of reproduction in *Daphnia pulex* which produced a second pulse almost as large as the yearly high. The brief periods between droughts in July and August showed a dominance of *Cyclops viridis* on the earlier date and an ascendancy of *Daphnia pulex* in August. The first date, February 3, on which water was found in 1939, after a five-month drought, showed a population very similar to that of the same date the preceding year. Total numbers were much alike (646 and 624), the predominance of canthocamptids was evident, and larval fairy shrimps were present, though fewer than in 1938. This may be due to the much colder weather in 1939, when the pond was covered with ice on that date. Subsequent behavior at this pond is rather similar in 1939 to that in 1938, as the tabular data show. The reduction in number following initial appearance may be referred in part to the influence of predators, such as the *Ambystoma* larvae. Until the reproductive activities of the inhabitants developing from dried eggs can begin, the population must fall off in proportion to its inability to obtain food and to its

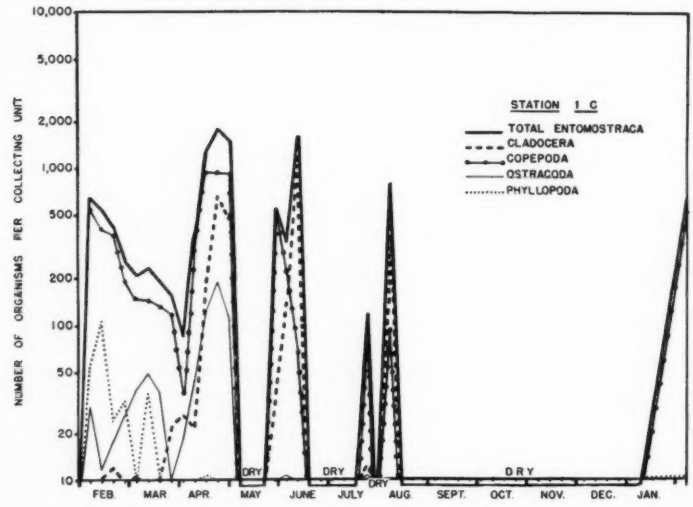

Fig. 4. Station 1C. Seasonal census of Entomostraca by major groups, Feb., 1938-Feb., 1939.

consumption by enemies. This diminution in number while the first-hatched forms were growing to reproductive maturity was noticeable both years. The peak of April 21, 1938, while composed of many species, owed its height mainly to the first broods of young which were then developing from the individuals which over-wintered in the dry state.

Station 2.—Prominent in the biotic picture at this pond was the algal population, which was richest of all stations in diatoms such as *Synedra, Fragilaria* and *Stauroneis*. Several desmids (*Pleurotaenium, Closterium,* etc.), the filamentous *Zygnema* and *Volvox* were common chlorophyll-bearers. The higher plants, chiefly *Ceratophyllum,* in addition to supporting diatoms, carried many stalked protozoans, the tube-dwelling rotifer *Floscularia,* and in June and July the bryozoan *Plumatella* in considerable quantities. *Pelmatohydra oligactis* was frequently present in spring, in great numbers in May, when it was feeding voraciously on Entomostraca. Small free-living rotifers such as *Noteus* were numerous at times. Chironomid larvae, nymphs of Odonata, Haliplidae, Notonectidae, and several species of Hydracarina were common arthropods. Only *Laevapex* and *Planorbis* among the molluscs were taken and these infrequently. Small fish occurred here, the only species taken being the common sunfish, *Eupomotis gibbosus*. Frogs were often seen on the margins, although tadpoles were not numerous enough to be taken in collection. The only other vertebrates seen were snakes (none captured for identification) and a muskrat, which had a dwelling at the upper end of the pond.

The following species of Entomostraca were taken at station 2: Cladocera — *Alona costata, Alona guttata, Chydorus globosus, Chydorus sphaericus, Leydigia quadrangularis, Pleuroxus denticulatus, Pleuroxus hamulatus, Scapholeberis mucronata,* and *Simocephalus serrulatus;* Copepoda — *Canthocamptus staphylinoides, Canthocamptus staphylinus, Cyclops albidus, Cyclops prasinus, Cyclops serrulatus,* and *Cyclops viridis;* Ostracoda — *Cypria elegantula, Cypridopsis vidua,* and *Physocypria globula.* Of these, *Physocypria globula* was the only form peculiar to this station; this may be due in part to its usual occurrence in slightly larger bodies of water than station 1 and 4, as it is commonly found in ponds and in small lakes.

This list is composed of one less species than that of 4 A, which is eight years old, while station 2 has been formed for about thirty years. The only station containing fewer species than station 2 is only four years old. It is possible that the fish exerted restraint on the establishment of any species at station 2 which was introduced only in small numbers. The only important predators at station 1 were larval and adult salamanders, which were not year-round occupants and thus would tend to be less destructive of newly introduced species than fish. The pond 4 A, lying but a few yards from each of several other pools of different ages, had a close and abundant supply of Entomostraca ready for introduction at the time of its formation, while such a source was not available at station 2.

Fluctuations in total number of Entomostraca at this station were extremely wide, from 10,378 on July 13, 1938, to 14 on November 11, 1938. Gross

changes can be observed by a study of the graphic representation (Fig. 5). For the first few weeks of collection, the predominant group numerically was that of young *Cyclops*, probably a mixture of *C. albidus*, *C. prasinus*, *C. serrulatus*, and *C. viridis*, of which the proportions could not be determined in the larval state. A brief pulse of *Chydorus sphaericus* and *Pleuroxus denticulatus* in mid-November produced a cladoceran increase which foreshadowed their winter dominance. This increase in Cladocera was both absolute and relative and very possibly came about partly in response to the copepod behavior. Young *Cyclops* was an unimportant group in winter, occurring only in small numbers, with occasional small sporadic rises, from December until the latter part of April. The chief Cladocera at station 2 were the small forms *Chydorus* and *Pleuroxus*, which are not much bigger than larval copepods, with which they probably compete for food. The continuance of reproduction throughout the winter in these forms, especially *Chydorus*, initiated the increase, which was probably accentuated by the survival of greater numbers in the absence of their competitors, the young cyclopids. During this winter maximum of Cladocera, the ostracod, *Cypria elegantula*, was present in small numbers but assumed no numerical importance until its reproductive period in late April. The greater relative and actual numbers of this species during the winter months at station 1, where it was then the dominant entomostracan, may be due in part to physical differences in the two stations. The chief reason,

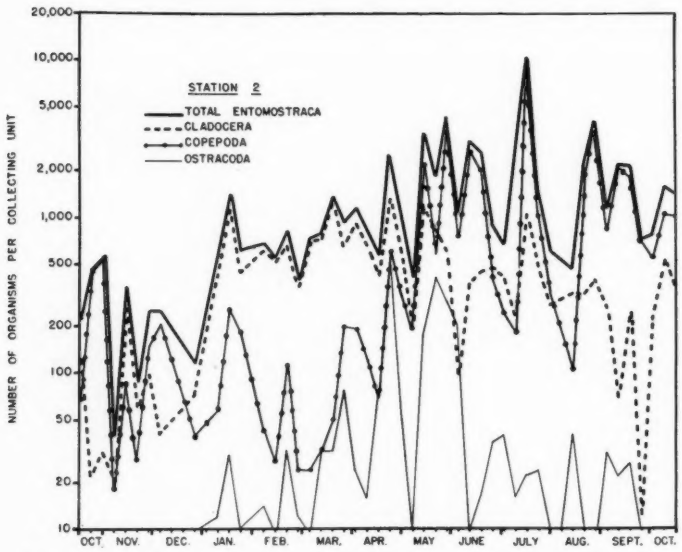

Fig. 5. Station 2. Seasonal census of Entomostraca by major groups, Oct., 1937-Oct., 1938.

however, appears to be that station 1 was occupied by Cladocera which did not survive the winter, except for a very few *Chydorus,* and by copepods whose reproductive activity was suspended by cold weather conditions in these small exposed ponds. *Cypria elegantula,* a natural cold water form, was thus dominant at station 1 until spring, when other Entomostraca again encroached on its food supply and when it began to be consumed itself by salamanders; while at station 2, with its less rigorous winter conditions and its population of cold-hardy Cladocera, no opportunity for *Cypria* dominance was afforded.

The general rise in total number in May was due to reproductive activity in all groups, but with a quick assumption of dominance by *Cyclops,* a dominance which was not lost again until the following winter. Although summer eggs were formed in both *Pleuroxus* and *Chydorus* at all times of the year, the number of offspring produced never approached that of *Cyclops* during its active period. It is important to realize, however, that the cladoceran young were held in the brood chamber during larval stages rather than existing as free swimmers like the copepod nauplii and hence were not counted until after release. Consideration of adults only shows a year-round dominance of Cladocera, especially *Chydorus sphaericus,* at station 2.

With the warm waters of late June, *Cypria elegantula* disappeared, and ostracod numbers for the rest of the period graphed were chiefly those of *Cypridopsis vidua,* with a very small contribution of *Physocypria globula* on one occasion. Totals in October, 1938, were considerably above those of October, 1937, but dropped shortly therafter to a winter level which was much lower, except for a *Chydorus* pulse on December 10, than that of the preceding year. The winter cessation of reproductive activity in *Cyclops* was again noted, as was the lack of prominence of *Cypria,* but data for the second year are not complete enough to trace such conditions in detail.

Station 3.—The biota of this station, in line with its age, was richest of all collecting places. The population of algae and higher plants requires no further mention, while animal forms can receive only the briefest treatment. Protozoa were well represented, especially by colonial flagellates, stalked infusorians, and shelled rhizopods such as *Centropyxis* and *Diffiugia.* The flatworm *Stenostomum* was common, as were free swimming rotifers such as *Cathypna.* The oligochaete *Stylaria* was frequently taken. Collembolans, *Haliplus, Dytiscus,* and a number of other aquatic insects were common, as well as a great many larval forms representing the Ephemerida, Odonata, Diptera, and Coleoptera. *Limnaea* was a fairly common mollusc. Fish are common at this station and were several times observed. Bluegills *(Helioperca macrochira)* and the common sunfish, as well as catfish were present and must exert some influence on the entomostracan numbers. Frog tadpoles were not uncommon. Of their feeding activities, little observation was made; one tadpole examined in the February 5 collection had an intestine filled with *Pleurotaenium* and *Closterium* and contained 1 *Daphnia longispina,* 1 *Cypria elegantula,* and 2 *Chydorus sphaericus,* all apparently quite undigested. Observations of frog tadpole intestines on a number of other occasions suggest limited

powers of digestion of Entomostraca, as living ostracods were found several times in the lower gut.

Of all the organisms mentioned the plants probably occupy the position of prime importance to Entomostraca. The living algae serve as a source of oxygen and to some extent as food, while the higher plants are oxygenators while living, and when dead, an extensive source of the decayed organic substances which are important in crustacean nutrition. The vertebrates are limiting factors of significance, but the services of the abundant flora in supplying food, oxygen, and shelter, outweigh their disadvantage, as the productivity of the pond shows.

The following Entomostraca were taken at some time during collection at station 3: Cladocera — *Alona affinis, Alona costata, Alona guttata, Alona quadrangularis, Alonella karua, Bosmina longirostris, Camptocercus rectirostris, Ceriodaphnia pulchella, Ceriodaphnia quadrangula, Ceriodaphnia reticulata, Pleuroxus denticulatus, Pleuroxus hamulatus, Scapholeberis mucronata, Simocephalus serrulatus,* and *Simocephalus vetulus;* Copepoda — *Canthocamptus staphylinoides, Canthocamptus staphylinus, Cyclops albidus, Cyclops ater, Cyclops bicuspidatus, Cyclops fuscus, Cyclops phaleratus, Cyclops prasinus, Cyclops serrulatus, Cyclops viridis, Diaptomus pallidus,* and *Diaptomus siciloides;* Ostracoda — *Candona crogmaniana, Cypria elegantula, Cypridopsis vidua,* and *Cyprinotus incongruens. Cyclops ater, Cyclops phaleratus,* and *Candona crogmaniana* were present in very small numbers. Ten of these species were found at no other station of the regular group, these being: *Alona affinis, Alona quadrangularis, Alonella karua, Bosmina longirostris, Camptocercus rectirostris, Ceriodaphnia reticulata, Daphnia longispina, Simocephalus vetulus, Diaptomus siciloides,* and *Cyprinotus incongruens.* However, the single collections made from other localities than the regular stations showed six of these species, leaving only the following four as exclusives at station 3: *Alona affinis, Alona quadrangularis, Alonella karua,* and *Ceriodaphnia reticulata.*

Although this list of 35 species was much the largest observed at any one place, it is composed of rather ordinary forms. At any one collection the greatest number of species taken was 16, of which 9 were Cladocera. The preponderance of cladocerans both in the species list and in the quantitative work is very evident. As Shelford (1911) points out, the youngest ponds ecologically have no or few ostracods, few Cladocera, and the most copepods; it is possible that this station is beyond the youngest stage, though only 70 years old. With the gradual introduction of more species of Cladocera competition with the existing copepods for food would inevitably appear. The excellent feeding mechanisms of the cladocerans might conceivably give them sufficient advantage over such forms as *Cyclops* with their rather inefficient methods (Birge, 1898) to lead to ultimate cladoceran dominance. Probably, however, changes in the physical character and nature of the food supply which occur as a pond matures are very important in the faunal shifts. Attempts to explain such a succession with the limited data at hand are mere speculations.

The only form apparently unusual for Ohio in the list is *Alonella karua,* which is described by Birge (1918) as occurring in Louisiana, Texas, and

Arkansas, not rarely, and in pools and lakes. However, as Fig. 10 shows, this form occurred here only in the warmest months, which would suggest either a recent introduction with lack of adaptation to cool water or an inherent lack of cold-hardiness. The *Daphnia longispina* of station 3 (see Fig. 10) appeared sporadically and showed no helmeting or head shape changes at different seasons. This is the expected condition in small bodies of water, as crest formation is characteristic of limnetic crustaceans. Also the *D. longispina* of station 3 was the type "primitiva" of Woltereck (1932), which is small, with a round head and no helmet, and occurs in small shallow lakes and in ponds, such as the artificial bodies of water in municipal parks. In such localities it usually lives near the surface of the water, where it was taken at station 3.

Numerical results for this station are shown graphically in Fig. 6. The low values in October and November, 1937, as at several other stations, may be in part actual and in part an effect of the collecting method. As mentioned previously, the first five weeks' collections comprised the organisms in 20 two-yard net hauls, while after that time the number of sweeps was reduced to 10. As the area reached by the net was never large, 20 sweeps may possibly have

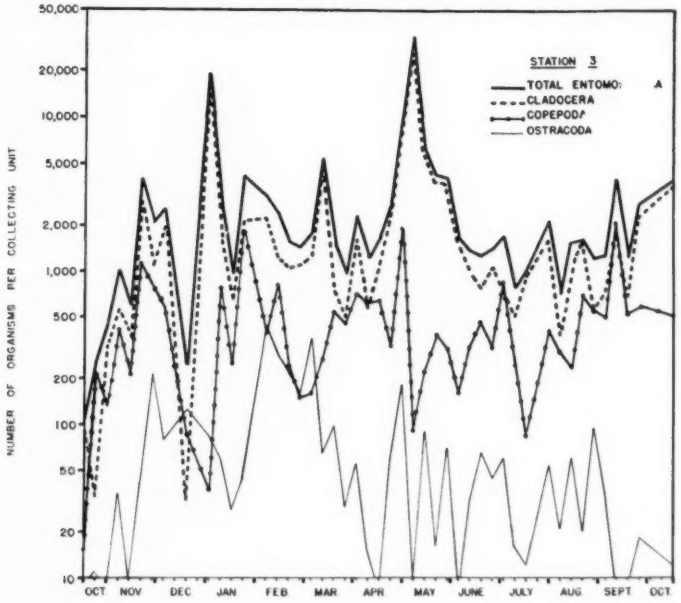

Fig. 6. Station 3. Seasonal census of Entomostraca by major groups, Oct., 1937-Oct., 1938.

somewhat depleted the stock of Entomostraca even before the collction was complete, with the result that the catch did not represent the actual number of organisms originally present. A reduction to 10 sweeps may have brought about a more accurate correspondence between catch and number of organisms actually present, as each of 10 sweeps could easily be taken at a new spot. The low totals of the early fall of 1937 are without other obvious cause, as no change in physical factors appears responsible.

The cladoceran preponderance throughout the collecting period was largely caused by a few species, which in order of importance were *Bosmina longirostris, Chydorus sphaericus, Ceriodaphnia pulchella* (in summer), and *Pleuroxus denticulatus*. Other species were never present in numbers sufficient to change the totals in a material way. The fall rise was chiefly a rise in *Chydorus sphaericus*, which continued at a rather high level throughout the winter, except for the latter part of December. The low point on the graph at that time was followed by an enormous increase of *Bosmina longirostris* (from 12 to 16,618 organisms) in the two weeks from December 18 to December 31. This corroborates the finding of Kofoid (1908), who states that *Bosmina* is capable of extremely rapid multiplication, which may be due in great part to increased food supply. That this may be the case here is suggested by the figures of the collection previous to the peak. The low total of 244 organisms on that date, of which only 32 were cladocerans, certainly reduced the consumption of food, which would increase its availability for any form not suffering from the cold. The bulk of the organisms (120) of that date were ostracods, principally bottom feeders, which would not tend to check the stock of food accessible to *Bosmina* in the upper waters. It is possible that this circumstance, plus the inherent capability of *Bosmina* for rapid multiplication, caused the sudden increase.

Of the copepods at station 3, the totals were determined by the number of young *Cyclops*, with little influence by any adult form except *Diaptomus pallidus* in the warmer months and until early in the winter of 1938. Slightly higher numbers of young cyclopids, added to the cold weather numbers of *Canthocamptus* and to slight increases in the numbers of adult *Cyclops viridis* and *C. serrulatus*, raised the Copepoda to a slight plateau in the first four months of 1938. The coincidence of this condition with the maximum cladoceran numbers (exclusive of the two *Bosmina* peaks) for the year produced a high general level for the first six months of 1938, when the total only once fell below 1000. Narrowing the annual pulse to a particular week or even to a month is difficult at this station. The greatest general increase in all species occurred on the week preceding the high of the year, which occurred on May 7. This rise was chiefly, as usual, *Bosmina*, but definite pulses of *Ceriodaphnia pulchella, Chydorus sphaericus, Pleuroxus denticulatus, Simocephalus serrulatus*, young *Cyclops, Diaptomus pallidus*, and *Cypria elegantula* occurred to bring the total on that date (April 30) to 13,050. The cause for the second *Bosmina* increase which led to the highest total of the observation period (32,250) the following week is not easily discovered. It was apparently not a food supply fluctuation, as the slight fall in numbers of *Bosmina's* chief

cladoceran competitors in the preceding collection (April 23) was only slight. Kofoid (1908) reports a maximum, very large, for *Bosmina* in the Illinois River in June. Such a pulse may have occurred here somewhat earlier, although if it is a temperature effect, the reason is not apparent, as even the June temperatures of station 3 were slightly less than those of Kofoid for the same month.

Ostracods were never important in the totals of station 3. The dominant species, as everywhere, was *Cypria elegantula*, which was replaced in importance by the other two species, *Cypridopsis vidua* and *Cyprinotus incongruens*, in late summer and early fall. As was pointed out previously, numerical dominance of *Cypria* seems to occur only under special circumstances, such as obtain at station 1, where other Entomostraca fail to survive the winter. At a station with great numbers of copepods and cladocerans, *Cypria* seems unable to assume an important numerical position even in its season of greatest activity.

Data for the second year were obtained at intervals too great to build a complete picture, especially with a rapidly fluctuating organism like *Bosmina* in a dominant position. Noteworthy are the later persistence of *Diaptomus pallidus*, the presence of *Camptocercus rectirostris*, and the larger numbers of *Bosmina longirostris* in the autumn of 1938 as contrasted to that of 1937.

Station 4 A.—The biota here was surprisingly varied, considering the recent origin of the station; but as mentioned above, the ready source of organisms from other ponds a few yards distant was probably responsible. Except in midsummer such algae as *Cosmarium, Closterium, Spirogyra,* and *Ulothrix* were common, while the same was true of the green flagellates *Euglena* and *Volvox*. Higher plants, chiefly *Elodea* and *Castalia* (see Fig. 2-A), were very abundant in the summer. *Hydra americana (Hydra vulgaris)* was common at times, occurring in very large numbers in April and feeding extensively on the entomostracan inhabitants. Several species of rotifers and the flat-worm *Rhynchomesostoma rostratum* were common in summer collections. The small oligochaete *Chaetogaster* accounted for the destruction of many Entomostraca during its period of abundance in May; two typical individuals contained respectively 3 *Chydorus*, 1 *Diaptomus*, and 1 nauplius, and 4 *Chydorus*, 3 *Cyclops*, and 1 *Pleuroxus*. The leech, *Glossiphonia*, was abundant in spring. The insect population was very large, the following orders being represented by larvae, nymphs, or adults: Hemiptera, Ephemerida, Coleoptera, Odonata, Diptera, and Collembola. Although certain insect nymphs are said to consume Entomostraca, the only group found to do so by the scanty investigations pursued in this study were not nymphs but the dipterous larva *Chaoborus*. Water mites and the amphipod *Hyalella* were other common arthropods at 4 A. *Physa* and *Viviparus* were common snails. A few goldfish were put in the ditch in summer to discourage the development of mosquitoes and may have been partly responsible for the midsummer drop in crustacean numbers. Frog tadpoles abounded, and adults of *Acris gryllus* and *Rana pipiens* were frequently observed.

The following species of Entomostraca occurred at station 4 A during the collecting period: Cladocera — *Alona costata, Ceriodaphnia quadrangula,*

Ceriodaphnia pulchella, Chydorus globosus, Chydorus sphaericus, Daphnia pulex, Graptoleberis testudinaria, Pleuroxus denticulatus, Scapholeberis aurita, Scapholeberis mucronata, and *Simocephalus serrulatus;* Copepoda — *Cyclops albidus, Cyclops fuscus, Cyclops prasinus, Cyclops serrulatus, Cyclops viridis,* and *Diaptomus pallidus;* Ostracoda — *Cypria elegantula* and *Cypridopsis vidua.* Two species, *Graptoleberis testudinaria,* often very numerous (up to 1140) and *Scapholeberis aurita,* of which but two individuals were found, were present exclusively at this station, never being taken even at the scattered collections from other localities than the regular ponds. While a numerical preponderance of Copepoda was often observed, a greater number of the species taken was Cladocera. This should not be the case if Shelford's (1911) premise is correct that copepods first populate a newly formed body of water. The presence of the nearby ponds of older establishment probably is responsible for this condition.

Chief interest in the quantitative results centers in the pronounced correlation between temperature and numbers. Compare the graph showing temperature (Fig. 8) with that of numbers (Fig 7) for an annual cycle at 4 A. The curve of totals takes its shape, except in midsummer, from the copepod population, which experienced a reproductive spurt in February to produce the only prominent increase in numbers before the water began to warm. While the copepods of numerical importance were chiefly young *Cyclops,* other groups were occasionally much larger. Thus the higher numbers from October, 1937, to the end of November were almost entirely due to *Diaptomus pallidus.* The Cladocera at this time were mainly *Chydorus sphaericus* and *Pleuroxus denticulatus* with some contribution by *Simocephalus serrulatus.* The ostracod peak was due almost entirely to *Cypridopsis vidua,* as the common cold-hardy *Cypria elegantula* was virtually absent. If *Cypria* had been the dominant ostracod here as it was at station 1, which showed similar severe winter conditions, a winter preponderance of ostracods might have been expected. However, at 4 A the greatest number of *Cypria* taken in one unit was 4, a quantity insufficient to swell the winter ostracod count, especially as cold weather pulses of *Cypria* appear due rather to a higher rate of survival of individuals hatched in summer than to an actual period of propagation in the autumn. Adult *Cyclops viridis* paralleled the increase in young cyclopids which followed the general winter reduction, but at a lower level, while *Diaptomus pallidus* was also important from early April to mid-May. This rapid recovery from the effects of cold put the copepods in a lead which was not overcome by Cladocera until July, when *Chydorus, Pleuroxus, Simocephalus,* and shortly,*Graptoleberis* pulses brought them to a high level. *Daphnia pulex* was briefly important in the spring, while except in the winter *Chydorus* and *Pleuroxus* vied for prominence, which was attained by *Pleuroxus* in the late summer coincident with development of *Graptoleberis. Simocephalus* was important only in the warmer months. The copepod level was increased again in July, August, and early September by the advent of young *Cyclops. Cypridopsis vidua* was responsible for the ostracod increases of summer, but these totals were relatively very small, as would be expected of ostracods in a pond of recent origin. All groups had fallen off at the last collection before drainage, which occurred

two weeks before the yearly cycle was completed, so that the last collection was made at this station after its refill in spring, 1939, which makes data insufficient for analysis of second-year conditions.

Station 4 B.—Biota other than Entomostraca was not extensive, as might be expected in a pond of recent origin, where wide fluctuations in physical

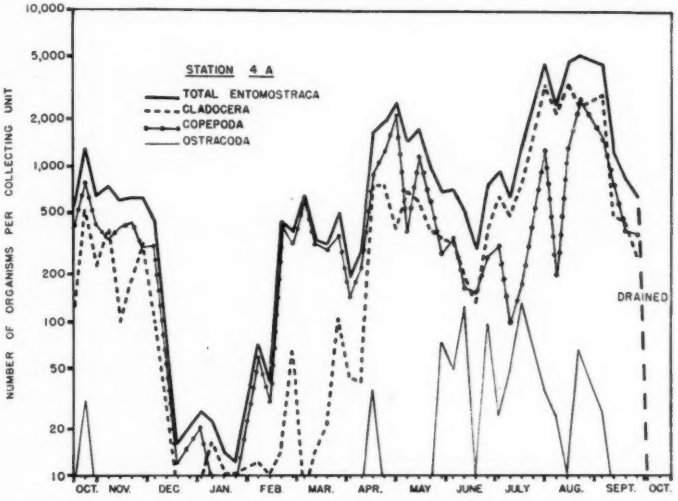

Fig. 7. Station 4A. Seasonal census of Entomostraca by major groups, Oct., 1937-Oct., 1938.

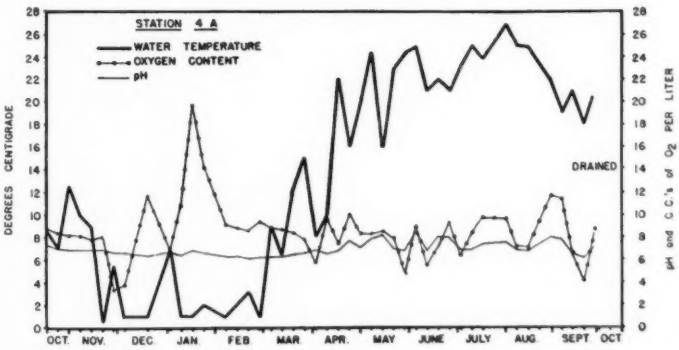

Fig. 8. Station 4A. Some physical factors, Oct., 1937-Oct., 1938.

escens complex to *A. canescens*.

conditions indicated that equilibrium had not yet been established. Among the chlorophyll-bearers, *Cryptoglena, Scenedesmus, Euglena, Pleurotaenium,* and *Cladophora* were occasionally observed, the latter in considerable quantity in September. The flatworm *Stenostomum* and several rotifers were occasionally taken. *Halipus, Chaoborus* (few), chironomid larvae, ephemerid nymphs, Notonectidae, and Gyrinidae were present among the insects. *Physa* was numerous in May, and many frogs appeared in spring and summer.

The following species of Entomostraca were taken: *Alona costata, Chydorus sphaericus, Daphnia pulex, Moina affinis, Simocephalus serrulatus, Cyclops serrulatus, Cyclops viridis americanus, Diaptomus pallidus,* and *Cypridopsis vidua.* Of these only *Daphnia, Cyclops viridis,* and *Moina* occurred in numbers sufficiently large to determine the totals. The paucity of species is of course referable to the recent origin of the pond. *Moina affinis* occurred exclusively at this station.

Total numbers here fluctuated widely. As Fig. 9 shows, copepods were most frequently dominant numerically, the large numbers taken being almost entirely young forms of *Cyclops viridis.* From October, 1937, until late May, 1938, the cladoceran population was represented by *Daphnia pulex,* the peaks of these being caused by the presence of great numbers of young. Until the winter temperature drop in December, when the numbers of young *Cyclops* fell off, the copepods were much more numerous than the cladocerans. From then until February, when, as at 4 A, young cyclopids again appeared, the *Daphnia* population was numerically dominant. It will be recalled that *Daphnia* did not survive the winter at station 1; its presence here may be due to the protective effect of the somewhat deeper water, the large quantities of oxygen, or the very abundant food supplied by the green flagellates and *Scenedesmus.* Food is probably not the least of these in importance. The March decline in both copepods and cladocerans was followed by a second period of rapid *Cyclops* reproduction which continued with varying intensity until July. After one further pulse the group fell to a level from which active reproduction did not lift it until the following spring. The *Daphnia* pulse for the year, of 23,670, was attained on May 14, during a temporary decline in *Cyclops,* which surpassed the cladocerans with the enormous total (highest single count on record in this study) of 41,740 three weeks later. The remarkable decline (from 23,670 to 32 in a single week) is apparently inexplicable except as a result of the introduction of a number of tropical fish. These were placed in the pond sometime near the first of June to keep down mosquitoes, but the exact date is not known; if it happened before May 21 the *Daphnia* drop would be explained by the relative ease with which they are captured by fish in comparison to the fast-moving young *Cyclops.* In any case, the disappearance of *Daphnia* was followed by the high *Cyclops* pulse mentioned; whether this was a result of increased availability of food for the copepods or simply the result of attainment of maturity by the cyclopids produced by the reproductive activity in March and April is not clear. Cladocerans were very few during this copepod wave, but in late June, a different species appeared and developed rapidly to the high total of 31,600 on July 30. This was *Moina affinis,* a

normal inhabitant of foul and stagnant waters in hot weather. How it escaped the fish, which were still present, is a question, but its glassy transparency may have been a factor in its favor. A similar relationship between *Daphnia* and *Moina* was reported by Pacaud (1939) in a small pond polluted by ducks and cattle, where *Moina* was the dominant form during the warmest season and *Daphnia* predominated at other times. *Moina* disappeared by mid-September, when the development of *Cladophora* provided shelter in which appeared *Simocephalus serrulatus* and *Alona costata* for the first time. Drainage of the pond prevented further observation until November. 1939 conditions were somewhat similar, as well as could be judged by the infrequent trips, but *Daphnia* was much less prominent than in the preceding year.

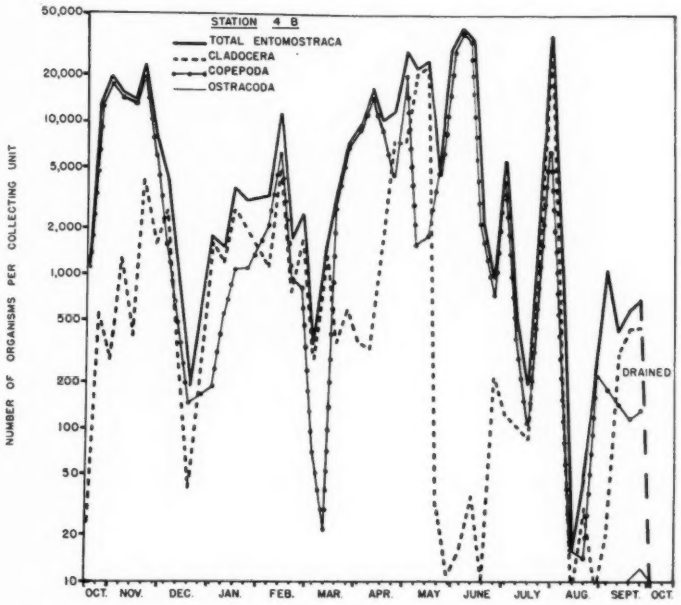

Fig. 9. Station 4B. Seasonal census of Entomostraca by major groups, Oct., 1937-Oct., 1938.

III. Occurrence of Species

The following species were collected in this work. Due to the somewhat limited nature of the environments from which collections were made, it probably does not include all the Entomostraca which occur in the Cincinnati area.

Entomostraca of the Cincinnati Region—Species List

BRANCHIOPODA

Phyllopoda

Eubranchipus vernalis

Cladocera

**Alona affinis*
**Alona costata*
Alona guttata
**Alona quadrangularis*
**Alona rectangula*
**Alonella karua*
Bosmina longirostris
Bosmina longirostris cornuta
Camptocercus rectirostris
**Ceriodaphnia pulchella*
**Ceriodaphnia quadrangula*
**Ceriodaphnia reticulata*
**Chydorus globosus*
Chydorus sphaericus
**Daphnia longispina*
Daphnia pulex
**Graptoleberis testudinaria*
Leydigia quadrangularis
*†*Macrothrix laticornis*
**Moina affinis*
*†*Moina brachiata*
Pleuroxus denticulatus
Pleuroxus hamulatus
**Scapholeberis aurita*
Scapholeberis mucronata
**Simocephalus exspinosus*
Simocephalus serrulatus
Simocephalus vetulus

COPEPODA[1]

**Canthocamptus northumbricus*
**Canthocamptus staphylinoides*
**Canthocamptus staphylinus*
Cyclops albidus
Cyclops ater
**Cyclops bicuspidatus*
Cyclops fuscus
Cyclops phaleratus
Cyclops prasinus
Cyclops serrulatus
Cyclops viridis americanus
**Cyclops viridis ingens*
Diaptomus pallidus
**Diaptomus sanguineus*
**Diaptomus siciloides*
**Osphranticum labronectum*

OSTRACODA

**Candona crogmaniana*
**Candona ohioensis*
**Cypria elegantula*
Cypridopsis vidua
Eucypris fuscata
Cyprinotus incongruens
**Physocypria globula*

**(Eucypris n. sp. 1—Furtos)*
**(Eucypris n. sp. 2—Furtos)*

*—new record for this area.

†—taken only at some locality other than the four regular stations.

1 For several reasons the changes in generic names of the Cyclopidae outlined by Kiefer (1927) were not used in this paper. In accordance with this usage, the following changes would be required: *Cyclops albidus* to *Macrocyclops albidus*, *Cyclops fuscus* to *Macrocyclops fuscus*, *Cyclops phaleratus* to *Ectocyclops phaleratus*, *Cyclops prasinus* to *Eucyclops prasinus*, and *Cyclops serrulatus* to *Eucyclops serrulatus*.

The species list presented in this study is composed of fifty-two species and three varieties, of which twenty-nine species and one variety are new records for the Cincinnati area. The list contains few species which are unusual or unexpected for this region, in accordance with the recent origin of the collecting sites. Unless particular interest attaches to a species with regard to its unexpected occurrence or other peculiarity, it will not receive special discussion. A number of cases requiring such comment have been considered previously in the description of individual stations when special conditions made such procedure more logical.

The prominence of the genus *Alona* in the species list suggests a position

of importance among the Cladocera which inspection of the numerical tables shows to be unmerited. In spite of the several species taken, the numbers were always small and the appearances scattered. The presence of *Alona affinis, A. guttata,* and *A. quadrangularis* only in the larger ponds of the study, with *A. costata* indifferently distributed in this respect and *A. rectangula* confined to the small pools of station 1 is an interesting condition. The difficulty in distinguishing certain of these species, which necessitated high power examination, may have distorted their ratio in counting to some extent, but the nature of their distribution would not be affected. As these species of *Alona* are all described by Birge (1918) as common and several are mentioned as very abundant, the small numbers taken here are somewhat unexpected. The possibility of less adequate powers of dispersal than such forms as *Chydorus sphaericus* or *Daphnia pulex* affords an explanation on the basis that by the time *Alona* arrived at these newly formed ponds the cladoceran population was so well established that the new genus has not yet attained prominence. The somewhat limited food supply in these small bodies of water may prevent the simultaneous occurrence in great numbers of two genera such as *Alona* and *Chydorus* or *Bosmina.*

The occurrence of the southern species, *Alonella karua,* at station 3 has already been mentioned and its prevalence only in the warmest season pointed out, a peculiarity which lends credibitilty to its presence here.

The only *Ceriodaphnia* of numerical importance was *Ceriodaphnia pulchella,* although here, as in the case of *Alona,* necessity for high power examination to distinguish *C. pulchella* and *C. quadrangula* may have produced slight distortion in the true ratios. In view of the more frequent appearance of *C. quadrangula* (or its large variety, *C. scitula*) in special lists, the dominance of *C. pulchella* observed here is interesting.

Macrothrix laticornis, never found at the regular stations, was taken in very small numbers from a large pond just across the Ohio River from Cincinnati on March 13, 1939. The conspicuous absence of the family Macrothricidae in the usual collections is less strange than it first appears. The group contains many lacustrine members and many of limited distribution of which the latter fact suggests powers of dispersal inadequate for appearance in ponds of recent origin.

Moina brachiata was found only once, in a very foul and muddy old canal bed on May 21, 1937. This appearance was slightly earlier in the year than that of the other species, *M. affinis,* which populated the regular station 4 B in the summer of 1938. The presence of ephippial eggs possibly attested to the foulness of the water. The pH was 8.4, as would be expected where a form usually frequenting alkaline water occurred.

Pleuroxus hamulatus is recorded by Birge ((1918) as a coastal form from New England and the southern states with no reports from the north central region. Turner's (1892) report of *"Pleuroxus hamatus"* in the Cincinnati region may have been thought to refer to Birge's old species by that name,

although the descriptions given by Turner of the discrepancies between that form and his specimens seem to point to its being the present *Pleuroxus hamulatus*. Its occurrence at three stations studied here, especially frequently at station 2, intensifies this opinion and suggests the necessity of an extension in the recorded distribution.

Scapholeberis aurita is included in the list on the basis of but two observations, on July 9 and August 25, 1938, on each of which dates but a single individual was found at station 4 A. It is regrettable that neither of these specimens was kept, as the preserved material did not disclose their presence. The species would be omitted from the list except that the recorded comments indicate that the identification was quite certain. It is somewhat unexpected but not incredible to find it here, as the species is reported (Birge, 1918) as not common and occurring in weedy pools and lake margins in the northern states.

The dominance of *Canthocamptus staphylinoides* over *C. staphylinus* both in numbers and in season of abundance was a rather unexpected condition observed wherever they appeared together. Quite frequently taken was a type apparently similar in all respects to the ordinary *C. staphylinoides* except for eight spines rather than six or less on the anal plate. These were large spines, quite different in appearance from the small and numerous ones of *C. staphylinus* and identical with those of the usual *C. staphylinoides* except in number. These individuals were included in the counts under *C. staphylinoides* without separate designation for the sake of simplicity though it is possible that further study may show the necessity for giving them racial, or, doubtfully, varietal value. The presence of *C. staphylinus* and *C. staphylinoides* to the exclusion of *C. minutus*, which Marsh (1918) records as the most common species, found everywhere in the northern continents, is an interesting local condition. *C. northumbricus*, which he reports as, next to *C. minutus*, the most widely distributed species of *Canthocamptus* in North America, was taken only at the small temporary pond 1 C, while the other species of the genus were found at four stations.

The occurrences of *Cyclops ater* at station 1 C have already been mentioned. It was also found at station 3 on a single occasion in the autumn of 1938 (Nov. 30). Whenever found, this species occurred in very small numbers (usually one in the entire collection). This is not unexpected, as it is said to be, in spite of its wide distribution, a rare form.

Cyclops phaleratus has been mentioned already in connection with the description of station 1 C. It also was found on one occasion at station 3, on November 3, 1938. It is a commentary on the slow dispersal of these two uncommon forms — i.e., *C. ater* and *C. phaleratus*, that they were found only in the oldest (70 years) of the artificial ponds and in a natural temporary pool which has probably contained water annually for a much longer period.

The common variety of *Cyclops viridis* in this locality is as might be expected *americanus*. *Ingens*, the large type similar to the European *gigas*, was taken only at 1 C, where its large size (usually about 2.5 mm.), beautiful

reddish coloration, and rather large number made it a conspicuous member of the population of this vernal pool. The variety *parcus* was never observed, but as Chambers (1912) indicates that the two varieties are never found together and as examinations always showed *americanus*, except at 1 C, this is not unnatural.

The rarity of *Diaptomus siciloides* is somewhat unexpected in view of the comment of Marsh (1918) that it is the species most likely to be found in the Ohio valley, although not the exclusive form. In addition to its infrequent occurrences at station 3, it was taken at a somewhat similar pond about two miles distant from 3 in small numbers on October 1, 1938. The greater importance of *D. pallidus* in this area is revealed in the notes of Turner (1892) who records it as the only species observed.

The scarcity of ostracods, both in total numbers and in number of species, is probably referable to the recent origin of the ponds studied, in view of Shelford's (1911) comment that ostracods are the last group of Entomostraca to populate a newly formed habitat. Difficulties of identification and the fact that larvae were sometimes taken although adults capable of recognition were absent may have prevented maximum expansion of the list. Two of the forms collected, *Candona ohioensis* and *Physocypria globula*, were species first discovered in Ohio and described by Furtos (1933).

Of the entire list, only three species — *Chydorus sphaericus*, *Cyclops serrulatus*, and *Cyclops viridis* were common to all stations. Except for pond 4 B, two more species were universally present — *Cyclops prasinus* and *Cypria elegantula*. Found at all but two stations were *Daphnia pulex* (not at 2 or 3), *Pleuroxus denticulatus* (not at 1 C or 4 B), and *Cyclops albidus* (not at 1 C, 4 B). The temporary pond 1 C, while contributing several species peculiar to itself, failed to contain some common species which may be unable to endure drying. At the other extreme from the three ubiquitous species were nine forms which occurred each at a single locality, these being: *Alona affinis* (station 3), *Alona quadrangularis* (3), *Alonella karua* (3), *Ceriodaphnia reticulata* (3), *Scapholeberis aurita* (4 A), *Canthocamptus northumbricus* (1 C), *Diaptomus sanguineus* (1 C), *Osphranticum labronectum* (1 C), and *Physocypria globula* (2). Several other species, such as *Camptocercus rectirostris* and *Daphnia longispina*, occurred at only one of the regular stations (3) but were taken elsewhere.

Comparison of the species list presented here with other local records brings out many points of similarity and some of difference. Chambers (1874) reported *Eubranchipus vernalis (Branchippus vernalis)* in a temporary pond near Covington, Kentucky, a few miles from Cincinnati and a single specimen of *Estheria* of unknown species in a small pool in the same region. The present work confirms the record of the fairy shrimp, but *Estheria* was never taken. Pearse (1918) stated that no species of the genus *Estheria* is found east of the Mississippi River. Chambers (1881) described a new species of the Harpacticidae (Copepoda) from saline waters at Big Bone Springs, Kentucky. As he stated that in his opinion the new species, *Tachidius* (?) *fonticola*, did not occupy an area of the earth's surface more than two yards square and that

covered with salt water, it is not surprising that it did not occur in the ponds of this study. Chambers' other new species (1881), *Diaptomus kentuckyensis* from Covington, Kentucky, was recorded fourteen years later by Herrick (1895) as not recognizable, and nothing answering its description occurred in the present collections.

Hunt (1882) listed nine species of Entomostraca for Cincinnati and vicinity, of which five were frequently found in this study. The phyllopod, *Branchipus stagnalis*, of his records has not since been taken here. His record of *Camptocercus macouris*, which may have been intended for *C. macrurus*, seems due to a change in species name since the date of his writing. *C. macrurus* is now reported (Birge, 1918) as very rare, while *C. rectirostris*, the species of station 3, is said to be common. The fact that Turner (1893) also listed *C. macrurus* as occurring locally and the fact that Herrick (1895) recorded *C. macrurus* as universally distributed and *C. rectirostris* as not yet recognized in America further indicate a change of the name of the species. Moreover, Herrick's figure labelled *C. macrurus* has the number of post-abdominal denticles characteristic of *C. rectirostris* rather than of *C. macrurus*. It seems probable from this information that both Hunt's and Turner's records of *C. macrurus* refer to the species now described as *C. rectirostris*. Hunt's *Cyclops quadricornis* is referable to the present *C. strenuus*, which so far has been found in the United States only in a pond in the Adirondacks (Marsh, 1918); this record is probably in error. Thirteen years after Hunt's report of *Diaptomus castor* Herrick (1895) wrote that all references to *D. castor* in America were erroneous, and Marsh (1918) did not list the species.

Turner (1892, '93, '94, '95) reported thirty-one species of Entomostraca as occurring in the Cincinnati area. Twenty of these are identical with or can be related to (see *Camptocercus macrurus*, above) species taken in the present collections. A partial explanation for the absence from his list of thirty-two species which have now been found to occur locally is his limited period of collection. His admittedly incomplete report was based on three months' study, apparently in the summer months, which prevented the taking of many forms occurring principally at other seasons. Only the species taken by him and not discovered in the present investigation will be discussed.

Turner (1892) reported three species of *Alona*, of which one species, *A. glacialis*, was recognized three years later by Herrick (1895) as a variety of *A. guttata*, with the suggestion that combination with that species was advisable. The variety is not mentioned by Birge (1918) and on the basis of this somewhat negative evidence, *A. guttata* is not treated in the present species list as a new form for this area. Turner's report of *A. intermedia*, a rare species in this country, is not confirmed by this work. *A. porrecta*, which Turner lists, is of problematical existence and nothing conforming to the descriptions of it was found. Named and described by Birge (1878), the species was nevertheless omitted without comment from his (1891) list of Cladocera from Madison, Wisconsin. It was not included in his account of the Cladocera, Ward and Whipple, (1918); and, as Herrick (1895) said, "we are left in doubt whether the species is abandoned or not."

No particular reason can be assigned to the absence from the present list of *Dunhevedia setigera,* reported by Turner (1893) except that it is stated to be uncommon. While the species of *Moina* reported by him was not taken, two other species of *Moina* were found, and as the genus as a whole is rather widely distributed this condition is not surprising. Turner's (1892, '93) report of *Sida crystallina* is not corroborated, although the species is a common one among weeds in ponds and lakes. It may have been found by him in somewhat older ponds than the present series of stations. *Cyclops fimbriatus,* reported by Turner (1892), is said by Spaeth (1914) to be the rarest *Cyclops* in the vicinity of Haverford, Pa. As Turner reports it as abundant in all ponds, and as its eight-segmented antennae, a diagnostic character, are also possessed by the young forms of other species of *Cyclops,* the possibility suggests itself that his records may have been based not on adult forms of *C. fimbriatus* but on young forms of some other more common species. *Eucypris virens (Cypris virens)* reported by Turner was not found in these colletcions nor was it observed by Furtos (1933), who stated that it was doubtfully present in Ohio. *Cyprinotus crenata* (*Cypris crenata* Turner) was not recorded in this study, although its description was written from species taken in Cincinnati. Turner reported it as abundant in a few undesignated ponds, which almost certainly were not sampled in connection with this work. *Cypria inequivalva,* also named and described by Turner (1893) for this area, was not observed. Furtos (1933) reported his description as somewhat confusing and did not find either this or the preceding species in her collections. *Chlamydotheca speciosa* (described erroneously by Turner as the new species *Cypris herricki*) was taken by him only in a canal bed which has since been filled, and since his record the species has not been reported for Ohio.

In addition to differences in regard to species collected between the present report and those of Turner, there are several discrepancies of varietal rank. His record of *Cyclops viridis parcus* (then *C. parcus*) has not been confirmed. The large variety *ingens* of *Cyclops viridis* probably was not taken by Turner, as his (1892) record of *Cyclops viridis* (unqualified) is more apt to mean the common *C. viridis americanus.* His record of *Bosmina cornuta* should be referred to the present *Bosmina longirostris cornuta.*

Priority is due to Chambers (1874) in recording the local occurrence of *Eubranchipus vernalis,* to Hunt (1882) in listing *Bosmina longirostris, Camptocercus rectirostris* (not certain), *Chydorus sphaericus, Cyprinotus incongruens (Cypris fusca), Cypridopsis vidua (Cypris vidua),* and *Daphnia pulex,* and to Turner (1892, '93, '94) for the additional sixteen species and two varieties previously recorded (given without asterisks in the species list).

IV. Seasonal Distribution

Seasonal distribution, one of the chief considerations of this work, has been very little treated in the foregoing account. The graphs (Figs. 10 and 11) show the results of this phase of the study sufficiently well for each species so that only general comment is necessary. In examination of these figures it is very important to realize that they do not present any evidence as to the

number of each species present at any one time but only indicate that it was observed either in the living material, the counting sample or both on that date at some station. Forms never taken at the regular stations *(Macrothrix laticornis, Moina brachiata)* and varietal distinctions were not included in the graphic representation nor were the records of *Scapholeberis aurita,* which, as described, were based upon only two individuals. Reference to seasonal variations in physical conditions, chiefly temperature, is desirable in interpreting the charts.

The species recorded here fall, with certain exceptions, into four fairly well defined groups with regard to seasonal occurrence. Species found only once or twice in the entire year of seasonal recording in the graph need no further comment on time of occurrence, and only the rather common inhabitants give sufficient data for adequate interpretation. In other words, a species taken

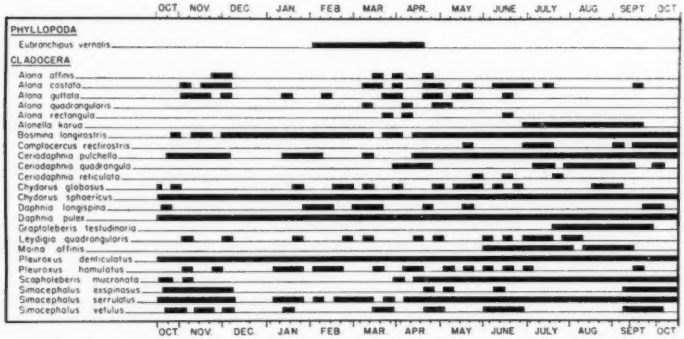

Fig. 10. Seasonal distribution of Entomostraca by species; Phyllopoda and Cladocera, Oct., 1937-Oct., 1938. Combined data from all regular stations.

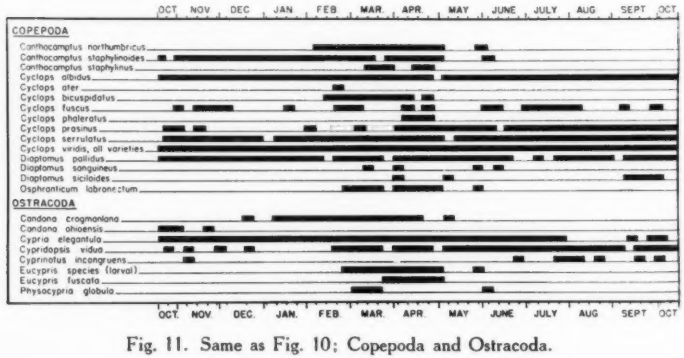

Fig. 11. Same as Fig. 10; Copepoda and Ostracoda.

only a few times and in small numbers may indeed have been more prevalent at those seasons but may also have occurred in small numbers on many occasions when it was not taken; hence seasonal analysis on such a basis is unwarranted. The following groupings do not therefore include all the species taken.

A. Forms of constant occurrence.

Cladocera	Copepoda
Chydorus sphaericus	*Cyclops albidus*
Daphnia pulex	*Cyclops viridis*
Pleuroxus denticulatus	*Cyclops serrulatus*

The cladocerans showed a tendency toward higher numbers at most stations in the spring, as did young forms of *Cyclops viridis*, although reference to the results at separate stations will show wide variations in this respect. The behavior of *Cyclops albidus* is interesting in view of the comments of Elton (1929), who regards it as predominantly summer species. He grants that it can be found all the year round but cites a pond studied by him where it never occurred in January, February, and March, and suggests that greater numbers always occur in summer even where it may also be taken in the cold months. This species was taken here at some station, often at several, every week of the winter of 1937-'38. The absence of it from the last week's collections in April, the only absence of the year, was apparently mere chance, in view of the rather small numbers in which it usually occurred. It was found in late April, 1939, at 1 A. It is true that at some ponds (1 B, 4 A) the summer numbers of *C. albidus* were larger than those of winter. At station 2, however, the largest single total of the species (40) was taken on January 12, while it was absent during the summer months. Station 3 gave a similar picture, with the largest total (108) of *C. albidus* on November 20 and none in late July and August of the following year. The six months from October, 1937, to March, 1938, gave a total of 365 *C. albidus*, while the next six months of that year, up to October, 1938, totaled only 219. Even excluding the one high count of 108 from the higher number, the results do not suggest a uniformly greater prevalence of *C. albidus* in the summer. The presence of *C. serrulatus* was so nearly constant that it should almost certainly go in this first group rather than in the next.

B. Forms not constantly present but occurring without pronounced reference to season.

Cladocera	Copepoda
Bosmina longirostris	*Cyclops fuscus*
	Diaptomus pallidus

This species of *Diaptomus* is recorded by Kofoid (1908) as not occurring in the Illinois River in February. One of its infrequent absences in this series of collections was also in February, and numbers throughout that month were somewhat reduced, although his report of other seasonal variations in *D. pallidus* is not borne out.

C. Forms with a tendency toward one or two periods of abundance but not limited to those seasons.

Organisms	Period(s) of Greatest Abundance
Cladocera	
Alona affinis, A. costata, A. guttata	spring and fall
Alona quadrangularis	spring
Alona rectangula	spring
Camptocercus rectirostris	summer
Ceriodaphnia (all species)	summer
Chydorus globosus	spring
Daphnia longispina	spring and fall
Leydigia quadrangularis	summer
Pleuroxus hamulatus	spring
Simocephalus serrulatus	summer
Simocephalus exspinosus	fall
Simocephalus vetulus	fall
Copepoda	
Cyclops prasinus	summer and fall
Ostracoda	
Cypridopsis vidua	summer and fall

Simocephalus vetulus and *S. exspinosus* are difficult to place but seem to belong here because of their greater abundance in autumn, although, as mentioned under station 1 A, the seasonal distribution of *S. exspinosus* was very different the second year of the study. *Cyclops prasinus* and *Cypridopsis vidua* were found in some numbers at other seasons than summer and fall but were absent or infrequent in winter. This condition of *Cyclops prasinus* is at direct variance with the report of Kofoid (1908), who found it only from September to March, when the temperature usually was below 40° F. Here, the warm months showed *C. prasinus* in far greater abundance, and it was absent in winter. The highest numbers at station 2, for instance, were found on August 17 and August 24, with temperatures above 70° F., and it was absent from that station from November 10 to March 3. Spaeth (1914) reported, in accordance with this record, that few *C. prasinus* were found in the vicinity of Haverford, Pa., in the winter.

D. Forms with rather sharply limited seasonal distribution. This, like C, is a large group and is divisible into sections depending upon the time at which the periods of frequency fall.

(1) Spring species

Phyllopoda	*Diaptomus sanguineus*
Eubranchipus vernalis	*Osphranticum labronectum*
Copepoda	**Ostracoda**
Canthocamptus northumbricus	*Candona crogmaniana*
Cyclops bicuspidatus	*Eucypris* (all species)

These forms, except *Candona crogmaniana* and *Cyclops bicuspidatus*, will be recognized as characteristic of vernal temporary pools. The occurrence of *Canthocamptus northumbricus* was similar here, although it is not recorded as typical of such situations.

(2) Winter species

Copepoda	**Ostracoda**
Canthocamptus staphylinoides	*Candona ohioensis*
Canthocamptus staphylinus	*Cypria elegantula*

No species occurred exclusively in the winter but several were characterized by existence only in cool water, appearing in the fall and disappearing as soon as the water was thoroughly warmed in spring. *Candona ohioensis* qualified for inclusion here on the basis of its appearance in fall but disappeared before the full onset of winter. Except for the larvae of *Cypria elegantula*, which prolonged its presence until July, it was typical of cool waters, as the adults rarely appeared after April except in small numbers.

(3) Summer species

Cladocera
Alonella karua
Moina affinis
Graptoleberis testudinaria
Scapholeberis mucronata

Ostracoda
Cyprinotus incongruens

Such forms often remained through September and into the first weeks of October, but disappeared with the coming of cold weather and did not appear until the water was thoroughly warm in summer. Individual differences in the times of these occurrences were characteristic of the various species, some disappearing a week or more before the temperatures dropped. *Moina* (most species) and *Scapholeberis mucronata* are recorded as typical of warm and stagnant water, but such behavior is not usually reported as characteristic of *Graptoleberis testudinaria*. The occurrence of *Alonella karua* only in warm waters has received previous comment (see station 3). *Cyprinotus incongruens*, although not constantly present in summer, occurred typically in the warm months.

In general these data on seasonal distribution are in accord with the work of previous investigators. Much more could be said by way of relating the material to the extensive results of Kofoid and others, but only outstanding cases have been selected for comment. Some discrepancies are certainly due to the local differences in climate and to peculiarities of the stations involved here. Inasmuch as no extended seasonal records either for this vicinity or for ponds of this type are in existence, further comparisons seem to be unprofitable.

Discussion

Although careful weekly determinations of the chief physical and chemical factors of each station were made, correlations between the occurrence of organisms and the measurements of turbidity, oxygen, carbon dioxide, and carbonates were ordinarily negative. Hydrogen ion concentration as exhibited by these natural environments appeared to possess slight importance as a limiting factor for many Entomostraca, although the results do not preclude influence upon certain species. Qualitative and quantitative aspects of entomostracan distribution showed definite correlation with the biotic character and age of the ponds particularly with temperature variations.

Since the importance of turbidity depends chiefly upon the nature of the suspended material, its significance varies. At most stations of this study turbidity was due to inorganic matter stirred from the clay or muck bottom, material which had no food value but might conceivably affect Entomostraca by interfering with the filtration apparatus or respiratory mechanism. No such

detrimental effect was observed, however. At station 2, for instance, on April 14, 1938, when the pond was so clear that no turbidity was measurable, the total number of Crustacea was 564; while on June 29, with the turbidity very great (3 inches), the total number was 680. Even when the turbidity was due in considerable part to organic materials which serve as food, such as the flagellates and bacteria of station 4 B, increased entomostracan numbers did not always parallel increases in suspended material. For example, on May 14, 1938, with the turbidity at 21 inches, 25,410 Entomostraca were taken, while one week later when the pond was much more turbid (5 inches), only 4609 Entomostraca were counted. The following week (May 28) the pond was much clearer (turbidity, 19 inches) and the crustacean numbers reached 28,332. It was true, however, that extreme clarity at this pond was often accompanied by reduced numbers of Entomostraca; but the same condition at station 3, where visibility was several feet at nearly every collection appeared to have no effect upon productivity. Such variable results make it impossible to credit the degree of turbidity with a direct influence upon the entomostracan populations observed.

Under all ordinary circumstances the ponds studied contained relatively large amounts of oxygen, although on a few occasions it was sharply reduced. On November 24, 1937, the time of the first appearance of ice at station 1, analysis of the water revealed no oxygen. Although dipterous larvae (*Chaoborus* sp.) and living Entomostraca were present, the Crustacea were considerably reduced in number. One week later the oxygen content measured 0.86 cc. per liter and the number was nearly quadrupled. On June 15, 1938, although the oxygen content was only 0.68 cc. per liter, over 1400 Entomostraca were taken, this being nearly seven times the number on December 1, when the oxygen content was similar. Four species of Entomostraca *(Daphnia pulex, Simocephalus exspinosus, Cyclops albidus* and *Cyclops* nauplii, and *Cypria elegantula)* were found when no oxygen was appreciable and five more appeared when less than 1 cc. per liter was present. At station 2 on September 15, 1938, the oxygen content measured 0.67 cc. per liter and a collecting unit contained more than two thousand Entomostraca belonging to the following species — *Chydorus sphaericus, Pleuroxus denticulatus, Simocephalus serrulatus, Scapholeberis mucronata, Cyclops prasinus, Cyclops serrulatus,* and *Cypridopsis vidua.* These low figures, except for the probably very brief period when no oxygen was measurable, are all considerably higher than the critical amounts previously reported (Pacaud, 1939) for various species of Cladocera. Apparently the environments studied almost never show an oxygen content low enough to limit the existence of Entomostraca. Since, however, samples for oxygen determination were taken near the surface, much lower values probably existed in other parts of the ponds, conditions which may have influenced the vertical distribution considerably. The most productive pond, 4 B, in numbers of Entomostraca, also showed the highest oxygen values. This high level immediately suggests itself as responsible in part for the great productivity, but comparison of the table for oxygen with the pulses dispels the idea of direct correlation. During five of the six weeks between April 30 and June 4 the number of Entomostraca was greater than 20,000 per

collecting unit; yet only twice during that time was the oxygen content above 10, while on May 7 it reached the all-time low (3.08 cc. per liter) for station 4 B, when the number of Entomostraca was 22,140. It is probably true that very low oxygen values would have been a much more serious check here where totals were so large than in a poorly populated pond. The results obtained at the stations studied thus indicate that here oxygen content is not usually a causal factor in quantitative or qualitative distribution of Entomostraca, as the amounts ordinarily present appear ample for their requirements.

No direct influence on entomostracan behavior could be traced to carbon dioxide, bicarbonates, or carbonates in the course of the investigation. As Shelford (1918) pointed out, carbon dioxide in small quantities is essential rather than detrimental to aquatic animals. With the exception of station 4 B, all ponds showed the presence of dissolved carbon dioxide on nearly all occasions. It is interesting that 4 B, the most productive pond in number of organisms, very seldom contained free carbon dioxide, as it was nearly always strongly alkaline. Apparently for the three most numerous species at this station *(Cyclops viridis, Daphnia pulex,* and *Moina affinis),* lack of carbon dioxide is not detrimental. Pacaud (1939) reported modification of phototropism with differences in dissolved carbon dioxide and variations between ephippiate and parthenogenetic females in ability to survive various carbon dioxide concentrations; investigations of this knd were not undertaken n this study. While the present evidence does not show a direct effect of carbonates, bicarbonates, and carbon dioxide upon Entomostraca, these substances are of some indirect importance as affecting the pH of the medium.

A tabular record (Table 1) of the pH range as observed for each species is presented. Such a table does not indicate any effects of pH upon the numbers present at any given value but shows merely the presence of some (usually more than one) individuals at each value designated. Many species, such as *Bosmina longirostris, Chydorus sphaericus,* and *Daphnia pulex* among the Cladocera, the copepods *Cyclops albidus, C. fuscus, C. serrulatus,* and *C. viridis,* and the ostracod *Cypridopsis vidua* showed a range from pH 5.5-9.5. As natural waters but infrequently show pH values more extreme than these, for such species hydrogen ion concentration can have little limiting effect. The fact that several of the species collected *(Osphranticum labronectum, Diaptomus sanguineus, Eucypris fuscata)* appear to be limited to acid water finds a readier explanation in their usual confinement to temporary pools, of which the one sampled, 1 C, was always acid. Many other species tolerated the greater part of the pH range and their absence at certain values was explicable as being due to other circumstances. *Scapholeberis mucronata,* for example, did not appear at any pH below 6.1, but as a summer species it was absent when greatest acidities occurred (pH 5.5 on January 29 at station 3 and on February 3 at 1 C). Similarly *Canthocamptus staphylinoides,* a cold weather form, ceased to appear as the water warmed whether pH changes occurred or not; its absence in alkaline water, which at the stations it inhabited were usual only in summer, was not a direct pH response. Several species occurred so infrequently in collections that their full pH tolerance could not be determined;

TABLE 1. pH Ranges of Entomostraca by Species.

Entomostraca	pH 5	6	7	8	9
	56789	0123456789	0123456789	0123456789	0123456–*
Eubranchipus vernalis	xx x	x x x xxx			
Alona affinis		x x x	x		
Alona costata	x	xxxxxxx	xx xx	x	
Alona guttata	x	xx xx x	xx xxx	x	
Alona quadrangularis		x	x		
Alona rectangula		xxx			
Alonella karua		x x	xxx	x xx	x x
Bosmina longirostris	x	x xxx xxxx	xxxxx	x xxxx	x x
Camptocercus rectirostris		x x x	x x		x x
Ceriodaphnia pulchella		x xxxxxx	x xxx	x xxxx	x x
Ceriodaphnia quadrangula		x x	x	x	x
Ceriodaphnia reticulata		x	x x	x	
Chydorus globosus	x	x xxxxx	x x xx	x	
Chydorus sphaericus	x x	xxxxxxxxxx	xxxxxxx xx	xx xxxxx	x
Daphnia longispina	x	x xxx x xx	xx	x	
Daphnia pulex	x	xxxxx xxxx	xx xx x xx	x xxxx x	xxxxx xx
Graptoleberis testudinaria		x xx	x x	x	
Leydigia quadrangularis		x xx x		x	
Moina affinis				x x	x x x
Moina brachiata				x	
Pleuroxus denticulatus	x	xxxxxxxx	xxxxxxx xx	x x x xx	
Pleuroxus hamulatus		xxx	x xxx	x	
Scapholeberis aurita		x		x	
Scapholeberis mucronata		xxxxxxxxx	xxxxx x x	x xxx x	x
Simocephalus exspinosus	xx	x x xxxxx		x	
Simocephalus serrulatus	x	x xxxxx	xxxxxxx xx	x xxx	
Simocephalus vetulus	x	x x xxxx	xx x	x	
Canthocamptus northumbricus	xx x	x xxx x			
Canthocamptus staphylinoides	xx x	xxxxxxxxxx	xxx		
Canthocamptus staphylinus		x xxxxxxxx	xxxx		
Cyclops albidus	xxx	xxxxxxxxx	xxxxxx xx	x x	x x
Cyclops ater		x x			
Cyclops bicuspidatus	x	xxx x xxx			
Cyclops fuscus	x	xxxxx x	x xxx	x x	x x
Cyclops phaleratus		x		x	
Cyclops prasinus		x xxx xxxx	xxxxxxx	x xx xx	
Cyclops serrulatus	x	xxxxxxxxx	xxxx xxxxx	x x xx x	xx x
Cyclops viridis	x x	xxxxx xxxx	xxxxx xxxx	xxx xx xx	xxxxxxxx
Diaptomus pallidus	x	x xxx xxxx	xxxxx x x	x xxx xx x	xx
Diaptomus sanguineus		xxx x			
Diaptomus siciloides		x x	xx x		
Osphranticum labronectum		xxxxx x			
Candona crogmaniana	x x	x xxx xxx			
Candona ohioensis	x	x xxxxx			
Cypria elegantula	xxxx	x xxxxxxxx	xxxxxxx	xx	x
Cypridopsis vidua	x	x x xxxx	xxxxxxx x	x xx x	x
Eucypris fuscata		xxxxx xx	x		
Cyprinotus incongruens		x	x x x	x xx	
Physocypria globula		x	x		

× indicates presence.

–* indicates a pH greater than 9.6 (above the highest available indicator).

a few isolated appearances at scattered pH values (see *Cyclops phaleratus*, *Diaptomus siciloides*, and others) do not preclude ability to survive at other levels. The frequent absence of these forms at pH readings well within their observed ranges indicates that other factors, such as actual rarity of occurrence or sensitivity to other environmental conditions, are operative. The table indicates a general tendency toward more frequent occurrence in acid water; whether this was a true response to pH alone cannot be determined from the present data. The fact that most of the ponds studied were acid intensifies this effect. The favorable influence of small amounts of free carbon dioxide (Shelford, 1918) may have led to greater abundance in acid water. such a response being to a specific chemical state which the pH reflects.

It is possible that in some cases pH actually sets a limitation upon entomostracan occurrence. The close correlation between the results of Pacaud (1939) and those of the present study in some instances suggests occurrence within a limited pH range for certain species of Cladocera. Pacaud found *Daphnia longispina* from pH 6 to 8.3; here the range was from pH 5.5-8.2. Pacaud reported *Ceriodaphnia reticulata* from pH 6.9-8.0; present observations show occurrence from pH 6.5-8.0. Pacaud found *Pleuroxus truncatus* from pH 5.9-8.5; the range of a related species, *Pleuroxus denticulatus*, in these observations extended from pH 5.5-8.7. Such correspondence in many occurrences definitely suggests a limiting effect of pH, but the effect of laboratory culture at other values upon survival and reproduction should supplement such data before such an influence is accepted as actual. The possibility that such apparent limitation is due to the accidents of natural distribution cannot be disregarded in view of the much wider ranges of certain species obtained in the present study as compared to the figures of Pacaud. Here *Simocephalus serrulatus* was found from pH 5.5-8.6; Pacaud reported it from pH 6.5-7.3. He found *Ceriodaphnia pulchella* from 4.7-7.7; in the present study the range extended from pH 6.2-9.5. Pacaud reported *Scapholeberis mucronata* as not occurring above pH 8.3; it was found here at pH 8.4, 8.5, 8.7, and 9.1. On the other hand, *Alona affinis* was not here observed above 7.1; Pacaud found it up to pH 8.3. The fact that here this species was found only in acid water thus does not necessarily indicate a requirement of low pH, the latter probably being merely an attendant condition to its infrequent appearance in response to some other influence.

Close agreement between the present results and those of Pacaud on the pH range of *Moina* seems to indicate a real tendency for several species of this genus *(M. brachiata, M. affinis)* to live only in alkaline water. But as *Moina* lives almost universally in warm, phytoplankton-rich ponds and pools where all or nearly all free carbon dioxide is consumed by the plants, the condition appears less likely to be a response to pH alone and more likely to depend as much or more upon temperature and food supply. The final solution to the problem of pH influence upon entomostracan occurrence lies in careful laboratory work. Until it has been proved experimentally that a species is incapable of flourishing at certain pH values, its absence from such waters cannot be taken as definite evidence of intolerance. Accidents of distribution, the age of

the environment, and seasonal conditions all complicate the problem in natural situations to such an extent that laboratory culture with pH the only variable appears essential to an understanding of the relations between Entomostraca and hydrogen ion concentration.

Temperature appeared to be the most important single physical factor in controlling entomostracan populations. Its annual cycle of course parallels that of light, which must also play a role, but there appears a sufficiently orderly arrangement of species in response to temperature alone to credit the latter with much independent influence. Undoubtedly temperature both directly and indirectly played a great part in inducing seasonal fluctuations in numbers and in controlling the appearances and disappearances of various species as the yearly cycle progressed. This is in accord with the report of Birge (1898) that temperature determined the reproductive rhythm and was the major factor in determining total numbers of Entomostraca in Lake Mendota. The section on seasonal distribution is, in substance, a description of the reactions of various Entomostraca to changes in environmental temperature, while the report of quantitative results describes the reactions of the population as a whole to the same factor. Comparison of the yearly quantitative cycle (Fig. 7) of station 4 A with the temperature graph (Fig. 8) for the same pond shows this relation between numbers and temperature very strikingly.

To cite a specific case of the influence of this factor, an example of dependence upon temperature is afforded by the southern species *Alonella karua* which has apparently extended its northward range to Cincinnati somewhat recently. This species appeared abruptly and in considerable numbers on July 2, 1938, at station 3, when the temperature was 26° C., a reading first recorded for that year in the observations of the preceding week. It appeared consistently at every collection thereafter until September 24, when the temperature fell below 20° C. for the first time. With this drop to 17° C. the species disappeared completely from collections, although it was several weeks before water temperatures became much further reduced. While it is true that temperature effects are not always so direct as this and often act through influence upon food supply, oxygen content, etc. rather than upon the organisms themselves, its primary role should not be minimized. As Brown (1929) pointed out, temperature alone is sufficient to explain the geographical distribution of a number of common Cladocera. Such effects could not, of course, be noted in a study limited to one locality, but comparison of figures for temperature with the records of seasonal occurrence and of fluctuations in numbers leaves little doubt that there an important role is played by temperature.

There is also a secondary or local relationship between the environmental temperature and the survival of certain Entomostraca occurring in deeper ponds where there is protection from the extreme seasonal variations. *Daphnia pulex*, for example, survived the winter in great numbers in the relatively deep pond 4 B, while it was absent in winter from the small pool 4 A, where shallowness of the water did not allow the refuge of more moderate bottom temperatures. Likewise the small cladoceran *Chydorus sphaericus* suffered little diminution in numbers in the winter in the deeper ponds 2 and 3, but

ceased to appear in the uniformly cold waters of the shallow pools of stations 1 and 4 A.

These results on the influence of physical factors are in agreement with those of Petersen (1926), who found that temperature and water level conditions were most important in affecting the general seasonal succession of organisms in a *Chara*-cattail pond, while pH and oxygen content frequently accompanied rather than caused the changes.

Numerical results are difficult to correlate at the various stations. Vernal pulses of varying extent and duration are perceptible at all stations but 3, which was also the only station failing to show large summer maxima. As pointed out previously, pulses appear most directly referable to temperature in such situations as these. That this is not the only factor is evident from the differences between stations with similar temperatures. Conditions of food supply, predators, competitors, other physical factors, and probably a number of unknown agents are also responsible in varying degrees.

While plants were probably important as food, either directly (algae and bacteria) or as sources of decayed and suspended organic matter, data here are insufficient to evaluate their role in population composition and fluctuations. The fact that the greatest numbers of Entomostraca consistently occurred in the pond (4 B) containing enormous numbers of green flagellates suggests the importance of some, at least, of the simple chlorophyll-bearing organisms as a source of food. In view of the previously cited work of Huff (1923), which tends to minimize the role of algae as entomostracan food, the absence of striking correlation between the algae present and the number of Crustacea is not unexpected.

The role of predators in affecting the numbers of Entomostraca has been considered only incidentally in this study. Positive evidence was obtained for the consumption of small Crustacea by several species of Hydratiae, by the small oligochaete *Chaetogaster*, by the larvae of the dipteran, *Chaoborus*, and by the young or adult forms of several amphibians (species of *Rana* and *Ambystoma*). How extensively these forms reduce the population of Entomostraca would be difficult to ascertain, but it is certain that definite effects must be exerted at such a station as 1, where all these predators but the oligochaete were present at various times and often in large numbers. The presence of large spring pulses of Entomostraca at this station in spite of the increased number of amphibian larvae at that time and the occasional occurrence of very large counts even in the constant presence of many *Chaoborus* indicate, however, that entomostracan populations are not greatly limited by the predators observed.

In the absence of quantitative evidence on food supply, competitive relationships among various Entomostraca cannot be accurately traced. Evidence that such conditions exist is not strikingly seen in this study, but some indication can be obtained, especially at the smaller ponds with their attendant limitations in food. An inspection of the numbers of two of the Daphnidae, *Daphnia pulex* and *Scapholeberis mucronata*, at station 1 A in the summer of 1938 shows that large numbers of both species did not usually

occur at the same time. As the numbers of *Daphnia* began to fall off in June, those of *Scapholeberis* rapidly rose to a high point of 888 on the day when *Daphnia* was lowest (70). With the beginning of the July pulse in *Daphnia*, numbers of *Scapholeberis* diminished and none was found on July 20, when a *Daphnia* count of 14,760 set the yearly maximum. As environmental conditions were unusually constant during this period, a state of competition for available food suggests itself as the most logical explanation.

Greatest single and average counts were recorded at 4 B, the youngest station, where the special conditions discussed were probably responsible. Second in this respect was station 3, the oldest pond; thus age alone is no criterion of quantitative production of Entomostraca. Fewest organisms were taken at 1 C, the temporary natural pool, where the short season and the very small area are limiting factors. 4 A was least productive numerically of the permanent stations, a condition referable in part to its small size with attendant limitation of food supply.

The particular species predominating at each station are also important in determining the time and extent of pulses, as inherent tendencies to react in definite and peculiar ways to various alterations in physical and other conditions are common characteristics of Entomostraca. The behavior of *Bosmina* and its responsibility for the otherwise inexplicable numerical peaks observed at station 3 have already been discussed. The peculiar propensity of *Cypria elegantula* for dominance only in cold waters from which other Entomostraca are virtually absent is another case in point. The conduct of *Moina affinis* at station 4 B is a further example of entomostracan peculiarity. This cladoceran appeared in small numbers for the first time on June 4, 1938, one week after *Daphnia pulex* disappeared from that pond. For six collections thereafter it was taken in small numbers, until, suddenly, following a collection of only 84 individuals, 31,600 young *Moina* appeared in a collection. This number was reduced to 408 the next week, none appeared at the following collection, and three months after its first appearance there was no sign that *Moina affinis* had ever populated the pond.

So much conflicting evidence on entomostracan quantitative cycles in large bodies of water, such wide variations in the results even of individual investigators, and the scarcity of such data for small ponds similar to those of this study make correlations between these results and those of other workers extremely difficult. The following brief outline developed by Birge (1898) on the basis of his work at Lake Mendota will be found not inconsistent with the present results if some minor changes in time are granted. A winter minimum from December to April gives way to a spring increase culminating in May, followed by a decline to June or early July. A midsummer maximum occurs in July, with a late summer decrease which is followed by an autumn maximum in September or October. By referring to the graphs of numerical results at each station a fair degree of correspondence is quite frequently evident; 4 B, for example, is described well by such an outline, except for the earlier appearance of changes explicable on the basis of warmer

temperatures in this region and for the special conditions existing there in midsummer. 4 A and 3 show somewhat different behavior.

A comparison of the graphic results with Kofoid's (1908) outline also shows some agreement. He ascribes the following behavior to the Illinois River Cladocera: greatest numbers occur between May and September or sporadically in winter (see *Bosmina* at station 3). Minimum records occur during minimum temperatures. Numbers increase slightly in March and April and rise steeply at 70° F. and above. Maxima occur in May and June with a midsummer decline except for pulses of *Moina* (see 4 B) or *Diaphanosoma*. Autumn pulses may show before a winter minimum appears. For copepods he finds a minimum in December to February with a maximum in late April or early May. Large numbers occur through the summer followed by a late fall decline.

While these general statements show agreement in a number of instances with the results presented here, arduous attempts at generalities on the basis of the present data are unprofitable. Conditions at the various stations find a much readier explanation when considered individually and in view of the special conditions obtaining there. It should suffice to say that the evidence given here indicates a tendency toward lower numbers in winter, the usual occurrence of spring pulses, a yearly maximum in summer, and fall pulses of varying magnitude. Variations upon or omissions of parts of this outline are due to conditions peculiar to the individual stations, in the description of which they have been considered.

Summary

1. Fifty-two species including three varieties of Entomostraca were collected. Twenty-nine species and one variety are new records for this area.

2. Regular weekly collections of Entomostraca and observations of physical, chemical, and biotic conditions were made at four stations for a one-year period, and these data were supplemented by monthly observations in the second year and by occasional trips to other situations.

3. Population counts as to species and numbers were made of weekly collections from four stations for one year and supplemented by monthly counts for the second year.

4. No general correlation between the measurements of turbidity, oxygen, carbon dioxide, or carbonates and the entomostracan population was observed.

5. Hydrogen ion concentration as exhibited by these natural environments appears to have slight importance as a limiting factor for many Entomostraca, although influence upon certain species is not precluded. Laboratory experiment is indicated as essential to solution of the problem of entomostracan relationships to pH.

6. The distribution of species and numbers is related to seasonal temperatures. On the basis of seasonal distribution the species present resolve them-

selves into four general groups which vary from constant occurrence to presence only within a sharply limited period of the year.

7. Special effects of temperature occur locally in respect to peculiarities of the environment.

8. The number and the variety of the species present are related to the age of the pond within the limits of the environments studied.

9. The importance of predators and the role of vegetation as food are recognized as problems worthy of further study.

10. The composition of the population and peculiarities of individual species are observed to be important factors in seasonal fluctuations, both in quality and quantity.

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APPENDIX

Physical and Chemical Factors of the Environment by Stations

Oct., 1937 - April, 1939

Station 1A—Physical and Chemical Factors

DATE	TEMPERATURE °C. AIR	TEMPERATURE °C. WATER	O_2 CC/L.	CO_2 CC/L. FREE	CO_2 CC/L. BOUND	$\frac{1}{2}$BOUND	pH	TURBIDITY IN INCHES
5/28/37	20	18	7.62	6.8	38.4	38.4	6.6	8
10/6/37	30	20	9.83	3.8	25.9	25.9	6.4	5
10/13/37	10	11	5.64	6.5	13.9	13.9	6.4	6
10/20/37	15	10	5.65	2.4	17.5	17.5	6.6	6
10/27/37	9.5	9	3.94	3.8	14.1	14.1	6.4	5
10/3/37	11	8	4.07	3.1	14.8	14.8	6.6	5
11/10/37	21	13	2.68	3.6	14.2	14.2	6.4	5
11/17/37	2	3	3.89	3.8	14.6	14.6	6.5	6
11/24/37	9	1–1	0	5.3	17.6	17.6	6.2	5
12/1/37	2	1–1	0.86	4.8	13.6	13.6	6.6	7
12/22/37	5.5	2–1	1.60	5.4	8.9	8.9	6.3	8
1/5/38	8	1–1	8.70	6.1	13.5	13.5	6.6	7
1/12/38	1	0–1	16.50	4.9	9.5	9.5	6.4	6
1/19/38	3	1–1	17.81	5.0	9.5	9.5	6.5	6
‡2/3/38	11	3–1	6.22	2.2	7.7	7.7	6.2	10
‡2/10/38	5	9	11.00	2.1	9.6	9.6	6.8	6
‡2/17/38	3	2	7.83	1.6	6.4	6.4	6.4	6
‡2/24/38	2	4	8.80	6.2	9.9	9.9	6.4	6
‡3/3/38	2	7	11.71	5.6	5.8	5.8	6.4	6
‡3/10/38	17	8	11.50	4.6	10.8	10.8	6.8	4
‡3/17/38	8	10	7.52	7.1	7.3	7.3	6.4	8
‡3/24/38	12	16	10.21	4.8	6.3	6.3	6.4	7
‡3/31/38	17	19	8.22	5.6	6.6	6.6	6.7	6
‡4/9/38	1	7.2	8.96	6.0	8.8	8.8	6.6	7
‡4/14/38	31.5	19	9.38	5.1	5.1	5.1	6.8	8
‡4/21/38	21	19	8.85	7.8	13.1	13.1	6.6	9
‡4/28/38	27	20	3.22	13.4	11.6	11.6	6.4	8
5/4/38	27	22	2.70	11.4	14.4	14.4	6.4	8
5/12/38	12.5	13	2.22	13.7	8.3	8.3	6.6	10
‡5/19/38	33	22	6.81	4.6	10.6	10.6	6.8	5
‡5/26/38	25	26	7.45	6.6	12.6	12.6	6.8	6
‡6/1/38	22.5	20	4.37	5.8	12.9	12.9	6.3	5
‡6/8/38	23	18.5	2.82	10.5	8.7	8.7	6.3	5
6/15/38	22	18	0.68	21.5	17.2	17.2	6.5	3
6/22/38	28.5	23	7.31	5.6	11.9	11.9	6.7	3
6/29/38	25	22	9.40	5.8	11.7	11.7	6.7	3
7/5/38	27	23	7.36	5.0	16.2	16.2	6.4	3
7/13/38	25	23.5	5.02	8.8	9.8	9.8	6.7	7
7/20/38	28.5	24	6.78	8.0	9.8	9.8	6.7	3

DATE	TEMPERATURE °C. AIR	WATER	O_2 cc/L.	CO_2 cc/L. FREE	BOUND	½BOUND	pH	TURBIDITY IN INCHES
7/28/38	26	23.5	4.35	9.1	12.9	12.9	6.7	12
8/9/38	26	24	3.25	7.6	9.6	9.6	6.5	5
8/17/38	28	26	6.31	8.4	14.7	14.7	6.3	6
8/24/38	24	21	2.76	6.1	21.5	21.5	6.5	12
9/1/38	22	18	3.63	8.6	12.4	12.4	6.4	12
9/8/38	25	21	1.28	5.3	9.0	9.0	6.3	14
9/15/38	18.5	20	3.48	8.1	10.6	10.6	6.4	13
9/22/38	14.5	12	7.24	6.6	8.3	8.3	6.6	12
9/28/38	22	18	6.88	6.1	13.22	13.22	6.2	11
10/12/38	21	15	5.14	10.1	8.3	8.3	6.5	..*
10/29/38	18	10	3.73	10.6	12.8	12.8	6.8	12
12/10/38	2	4.5	3.12	8.9	10.8	10.8	6.8	..
11/11/38	22.5	14.5	6.00	15.2	13.9	13.9	6.7	..
1/6/39	10.5	6	5.70	6.1	11.8	11.8	5.7	..
2/3/39	–1.5	1	6.95	5.0	12.6	12.6	5.6	12
3/3/39	9	8	5.24	5.6	5.7	5.7	6.0	12
3/30/39	5	4	6.22	5.8	11.2	11.2	6.2	10

ı—ice cover; ‡—observations taken at 1B which was continuous with 1A at that time; *—impossible to measure (disk still visible at bottom).

Station 1B—Physical and Chemical Factors

10/6/37	30	20	9.02	3.8	19.8	19.8	6.6	5
10/13/37	10	10.5	8.72	1.8	16.5	16.5	6.8	6
10/20/37	15	11	6.78	2.32	21.4	21.4	6.6	6
10/27/37	9.5	9	6.83	2.9	16.1	16.1	6.6	8
11/3/37	11	8	5.04	2.5	22.1	22.1	6.8	6
11/10/37	21	14	3.87	3.3	16.6	16.6	6.8	3
11/17/37	2	4.5	5.05	3.4	25.9	25.9	6.8	6.5
11/24/37	9	ı–ı	0	3.8	24.3	24.3	6.6	6
12/1/37	2	ı–ı	1.05	7.7	14.4	14.4	6.8	6
12/22/37	5.5	2–ı	5.36	4.3	13.9	13.9	6.2	6
1/5/38	8	ı–ı	9.65	5.5	13.9	13.9	6.4	7
1/12/38	1	0–ı	4.52	6.5	12.8	12.8	6.4	6
1/19/38	3	ı–ı	5.49	8.5	10.3	10.3	6.2	6
2/3/38	11	3–ı	6.22	2.2	7.7	7.7	6.2	10
2/10/38	5	9	11.00	2.1	9.6	9.6	6.8	6
2/17/38	3	2	7.83	1.6	6.4	6.4	6.4	6
2/24/38	2	4	8.80	6.2	9.9	9.9	6.4	6
3/3/38	2	7	11.71	5.6	5.8	5.8	6.4	6
3/10/38	17	8	11.50	4.6	10.8	10.8	6.8	4
3/17/38	8	10	7.52	7.1	7.3	7.3	6.4	8
3/24/38	12	12	10.21	4.8	6.3	6.3	6.4	7
3/31/38	17	19	8.22	5.6	6.6	6.6	6.7	6
4/9/38	1	7.5	8.96	6.0	8.8	8.8	6.6	7
4/14/38	31.5	19	9.38	5.1	5.1	5.1	6.8	8
4/21/38	21	19	8.85	7.8	13.1	13.1	6.6	9
4/28/38	27	20	3.22	13.4	11.6	11.6	6.4	8
5/4/38	27	20	4.25	7.3	14.4	14.4	6.3	8
5/12/38	12.5	12.5	3.45	9.6	9.8	9.8	6.5	7
5/19/38	33	22	6.81	4.6	10.6	10.6	6.8	5
5/26/38	25	26	7.45	6.6	12.6	12.6	6.8	6

DATE	TEMPERATURE °C. AIR	WATER	O_2 CC/L.	CO_2 CC/L. FREE	BOUND	½BOUND	pH	TURBIDITY IN INCHES
6/1/38	22.5	20	4.37	5.8	12.9	12.9	6.3	5
6/8/38	23	18.5	2.82	10.5	8.7	8.7	6.3	5
6/15/38	22	18.5	1.42	10.8	12.4	12.4	6.1	4
6/22/38	28.5	28	6.55	7.1	15.2	15.2	6.7	4
6/29/38	25	24	8.35	4.0	19.8	10.8	6.7	4
7/5/38	27	25	5.40	4.6	8.6	8.6	6.7	4
7/13/38	25	24	2.39	11.1	12.9	12.9	6.5	3
7/20/38	28.5	25	3.28	10.1	11.9	11.9	6.5	7
7/28/28	26	24	2.00	12.4	11.2	11.2	6.3	12
8/9/38	26	24.5	1.63	8.4	12.6	12.6	6.4	16
8/17/38	28	27	4.32	5.8	19.5	19.5	6.6	....*
8/24/38	24	21	6.21	8.8	15.1	15.1	6.5	....
9/1/38	22	19	1.88	8.3	6.3	6.3	6.4	....
9/8/38	25	21.5	1.87	9.0	8.6	8.6	6.5	....
9/15/38	18.5	21	2.76	6.1	13.2	13.2	6.4	....
9/22/38	14.5	12	5.17	6.8	8.6	8.6	6.7	....
9/28/38	22	18.5	8.38	5.8	9.1	9.1	6.7	....
10/12/38	21	15	5.98	8.8	9.4	9.4	6.4	....
10/29/38	18	9	6.28	7.1	9.9	9.9	6.6	....
11/11/38	22.5	12.5	3.13	7.2	11.4	11.4	6.4	....
12/10/38	2	3.5	4.64	6.8	9.3	9.3	6.8	....
1/6/39	10.5	5	5.00	15.7	10.4	10.4	5.6	....
2/3/39	–1.5	1–I	4.88	9.1	5.3	5.3	5.5	....
3/3/39	9	8	5.37	3.8	5.5	5.5	6.1	....
3/30/39	5	4	6.01	9.7	13.2	13.2	6.2	....

I—ice cover. *—impossible to measure (disk visible at bottom).

Station 1C—Physical and Chemical Factors

5/28/37	20	18	1.44	9.4	36.2	36.2	6.4	....*
2/3/38	11	6	3.79	3.3	9.1	9.1	5.5	....
2/10/38	5	10	5.30	4.4	15.0	15.0	5.8	....
2/17/38	3	4	4.86	3.3	10.2	10.2	6.0	....
2/24/38	2	4.5	2.33	16.9	5.8	5.8	6.0	....
3/3/38	2	6	4.33	16.4	11.0	11.0	6.0	....
3/10/38	17	9	5.79	8.7	6.3	6.3	6.2	....
3/17/38	8	9	8.60	12.4	9.4	9.4	6.0	....
3/24/38	12	15	2.27	9.4	7.6	7.6	6.0	....
3/31/38	17	20	5.84	6.3	6.3	6.3	6.2	....
4/9/38	1	7	5.02	9.6	6.8	6.8	6.1	....
4/14/38	31.5	21	4.61	11.6	10.1	10.1	6.4	....
4/21/38	21	18	3.21	12.1	10.1	10.1	6.2	....
4/28/38	27	21	1.79	35.5	13.4	13.4	6.3	....
5/26/38	25	21	2.78	11.3	11.6	11.6	6.2	....
6/1/38	22.5	19	1.24	14.4	13.7	13.7	6.2	....
6/8/38	23	18	1.79	16.8	9.2	9.2	6.1	....
7/20/38	28.5	23	1.31	10.2	8.7	8.7	5.8	....
8/9/38	26	24	0.85	9.8	10.7	10.7	6.0	....
2/3/39	–1.5	1–I	4.44	7.6	12.1	12.1	5.6	....
3/3/39	9	8	5.37	3.8	5.5	5.5	6.1	....
3/30/39	5	4	2.53	5.4	7.1	7.1	6.0	....

*—impossible to measure (disk still visible at bottom); I—ice cover.

Station 2—Physical and Chemical Factors

DATE	TEMPERATURE °C. AIR	WATER	O_2 cc/L.	CO_2 cc/L. FREE	BOUND	½BOUND	pH	TURBIDITY IN INCHES
10/13/37	10	12	11.08	2.7	28.5	28.5	7.2	16
10/27/37	10	10	8.46	2.9	28.3	28.3	7.2	15
11/3/37	12	10	8.89	2.4	19.6	19.6	7.2	15
11/10/37	22	10	8.92	1.7	27.0	27.0	7.3	24
11/17/37	1	4	9.73	3.6	16.9	16.9	7.2	----*
11/24/37	7.5	2–1	8.03	2.5	32.1	32.1	7.2	20
12/1/37	1.5	1–1	9.39	2.7	34.2	34.2	7.1	18
12/22/37	5	2–1	10.50	1.9	18.3	18.3	7.0	10
1/5/38	9	2–1	8.18	2.4	23.3	23.3	7.0	9
1/12/38	1	1–1	6.68	3.5	27.8	27.8	6.9	13
1/19/38	3	1–1	9.92	11.8	37.3	37.3	7.0	18
2/3/38	12	4	9.89	1.4	6.8	6.8	6.8	6
2/10/38	4	1–1	9.40	3.3	21.1	21.1	7.0	6
2/17/38	5	3	7.92	3.2	20.7	20.7	7.0	9
2/24/38	2	2	11.73	4.3	15.3	15.3	7.0	8
3/3/38	5	5.5	11.28	3.4	23.0	23.0	7.2	9
3/10/38	16	10	12.15	5.3	16.7	16.7	6.9	3
3/17/38	9	9	8.21	8.8	11.6	11.6	6.8	4
3/24/38	16	17	10.21	3.0	3.3	3.3	7.1	4
3/31/38	23	20	7.94	2.5	7.6	7.6	6.8	5
4/9/38	2	6	10.08	4.8	15.7	15.7	7.0	8
4/14/38	29	20	7.42	8.6	24.7	24.7	7.3	----
4/21/38	22	20	7.05	8.8	31.6	31.6	7.5	9
4/28/38	26	19	5.38	9.6	35.7	35.7	7.5	12
5/4/38	29	24	7.40	8.8	41.1	41.1	7.4	10
5/12/38	15	17	4.65	7.1	23.5	23.5	7.2	12
5/19/38	32	23	7.89	5.2	27.4	27.4	7.6	18
5/26/38	29	21	5.78	3.8	22.8	22.8	7.3	6
6/1/38	22.5	21.5	5.71	5.1	5.1	5.1	7.2	22
6/8/38	31	24	5.63	5.1	27.2	27.2	7.3	12
6/15/38	28	22	2.79	6.8	30.4	30.4	7.1	12
6/22/38	28.5	25	7.91	0	26.4	26.4	8.3	22
6/29/38	26	22	8.26	5.3	8.6	8.6	7.1	3
7/5/38	26	25	9.70	0	19.9	14.7	8.4	15
7/13/38	23.5	26	3.19	7.4	21.8	21.8	7.1	15
7/20/38	32	24	9.71	0	14.7	8.9	8.7	17
7/28/38	31	26	6.40	3.6	15.9	15.9	7.3	18
8/9/38	30.5	26	3.56	9.6	22.8	22.8	7.0	23
8/17/38	30	29	5.34	6.4	11.8	11.8	7.2	19
8/24/38	25	24	5.42	9.3	15.0	15.0	7.3	19
9/1/38	27	21	7.78	7.9	23.1	23.1	7.2	15
9/8/38	26	23	6.32	6.8	17.3	17.3	7.1	17
9/15/38	19	21	0.67	7.1	17.4	17.4	6.8	13
9/22/38	18	14	3.03	11.9	21.4	21.4	7.0	33
9/28/38	27	20	6.75	3.8	36.4	36.4	7.3	19
10/12/38	26	15	5.28	4.3	15.4	15.4	7.1	20
10/29/38	20	11	8.26	5.6	20.0	20.0	7.2	19
11/11/38	23	10	8.37	5.3	25.3	25.3	7.3	19
12/10/38	2.5	5	5.67	7.6	27.9	27.9	7.0	17
1/6/39	9.5	7	6.47	5.8	8.6	8.6	6.9	6
2/3/39	–3	1–1	11.50	5.0	10.6	10.6	6.9	12
3/3/39	10	7	9.89	6.0	11.1	11.1	7.0	15
3/30/39	5	5	8.42	5.2	11.7	11.7	7.0	9

*—impossible to measure (disk still visible at bottom); 1—ice cover.

Station 3—Physical and Chemical Factors

DATE	TEMPERATURE °C. AIR	WATER	O_2 CC/L.	CO_2 CC/L. FREE	BOUND	½BOUND	pH	TURBIDITY IN INCHES
10/16/37	13	11	4.87	4.3	28.6	28.6	6.8	....*
10/23/37	7	14	2.72	2.8	30.5	30.5	6.8	....
10/30/37	20	13.5	7.11	2.2	21.3	21.3	6.6	....
11/6/37	14.2	9	4.86	2.2	10.2	10.2	7.0	....
11/13/37	18	14	8.76	1.5	13.8	13.8	6.8	....
11/20/37	–6.5	0–1	6.47	5.2	12.1	12.1	6.6	....
11/27/37	11	2–1	4.89	6.6	15.2	15.2	6.5	....
12/4/37	3	2–1	16.40	5.4	19.8	19.8	6.7	....
12/18/37	2	1–1	12.10	2.8	7.1	7.1	6.0	....
12/31/37	9	6	5.59	3.1	8.7	8.7	6.3	....
1/8/38	–6	0–1	6.12	6.0	12.4	12.4	6.4	....
1/16/38	8.5	1–1	12.40	4.4	11.7	11.7	6.6	....
1/22/38	5	1–1	9.03	1.4	14.4	14.4	6.6	....
2/5/38	11	3–1	7.00	2.4	6.4	6.4	6.0	15
2/12/38	8	4	8.40	3.4	3.7	3.7	6.4	....
2/19/38	–1	2	11.80	1.3	4.8	4.8	6.6	15
2/26/38	1.5	1.5	11.71	5.5	8.8	8.8	6.4	....
3/5/38	21	10.5	12.00	3.0	6.4	6.4	6.3	....
3/12/38	20	8	10.23	2.1	5.3	5.3	6.4	....
3/19/38	21	12	13.21	1.3	4.3	4.3	6.6	7.5
3/26/38	13	15	14.20	3.0	4.6	4.6	6.9	....
4/2/38	3	9	10.54	3.6	4.4	4.4	6.8	14
4/10/38	19	13	11.93	3.5	3.5	3.5	6.6	....
4/16/38	28.5	20	12.90	1.2	7.6	7.6	8.4	....
4/23/38	19.5	17.5	8.72	3.1	6.3	6.3	7.1	....
4/30/38	22	20	6.60	6.6	9.0	9.0	6.9	....
5/7/38	25.5	20	8.30	2.0	8.1	8.1	7.4	....
5/14/38	15	15	8.02	4.5	7.6	7.6	7.4	....
5/21/38	19.5	21.5	5.71	5.1	15.4	15.4	6.2	6
5/28/38	26.5	23.4	6.58	2.0	6.3	6.3	7.0	....
6/4/38	25.5	23.0	8.61	4.3	8.8	8.8	6.8	....
6/11/38	22	21	4.26	2.5	7.6	7.6	6.7	....
6/20/38	24.5	21	4.70	5.0	7.3	7.3	6.7	....
6/27/38	24	26	9.10	0	15.2	3.8	8.5	....
7/2/38	27.5	26	6.90	3.5	11.4	11.4	6.9	....
7/9/38	28	26	11.40	0	11.1	2.5	9.1	....
7/15/38	26.5	28	11.10	0	9.4	3.3	9.5	....
7/30/38	34	30	11.70	0	10.2	7.3	8.4	....
8/8/38	29	27	10.20	0	11.6	0.2	8.7	....
8/16/38	27	26	6.00	4.8	23.2	23.2	7.2	....
8/24/38	28	24	8.41	1.5	9.2	9.2	8.6	....
9/1/38	24.5	22	7.05	5.8	11.4	11.4	7.4	....
9/10/38	23	23	6.80	1.3	10.6	10.6	7.3	....
9/17/38	18.5	20	4.20	5.5	13.1	13.1	6.6	....
9/24/38	24.5	17	8.30	3.3	12.6	12.6	7.0	....
10/1/38	17	16	5.90	4.5	13.2	13.2	7.0	....
10/20/38	8.5	14	8.10	4.3	11.6	11.6	7.4	....
11/3/38	24.5	14.5	7.80	1.3	8.7	8.7	8.2	....
11/30/38	6	3–1	10.11	2.5	11.4	11.4	6.6	....
12/28/38	–8	0–1	12.00	9.1	18.4	18.4	7.4	....
1/29/39	6	2–1	10.92	9.6	11.4	11.4	5.5	....
2/25/39	–2	3–1	11.00	2.9	6.8	6.8	6.2	....
4/10/39	7.7	11.1	9.83	3.7	8.4	8.4	6.6	....

*—impossible to measure (disk still visible at bottom); 1—ice cover.

Station 4A—Physical and Chemical Factors.

DATE	TEMPERATURE °C. AIR	WATER	O_2 CC/L.	CO_2 CC/L. FREE	BOUND	½BOUND	pH	TURBIDITY IN INCHES
10/10/37	20	14.4	5.56	0.5	33.4	33.4	7.1	....*
10/16/37	15	8.5	8.75	3.7	30.7	30.7	7.3	....
10/23/37	7	9	8.37	2.7	21.3	21.3	7.1	....
10/30/37	24	12.5	8.13	3.0	22.6	22.6	6.8	....
11/6/37	16	10	8.17	3.0	7.9	7.9	6.8	....
11/13/37	13	8	7.86	2.0	16.6	16.6	6.8	....
11/20/37	–6	0.5i	8.08	1.1	13.5	13.5	6.8	....
11/27/37	12.5	5.5	3.47	3.6	13.4	13.4	6.6	....
12/4/37	3.5	i–i	3.82	2.4	10.3	10.3	6.6	12
12/18/37	1	i–i	11.70	3.0	3.5	3.5	6.3	....
12/31/37	10	7	6.42	4.2	7.2	7.2	6.4	....
1/8/38	–5.5	i–i	10.92	6.5	7.6	7.6	6.5	14
1/16/38	8.5	i–i	19.70	1.3	11.5	11.5	6.8	15
1/22/38	6	2–i	14.20	2.0	8.0	8.0	6.6	15
2/5/38	12	i–i	9.10	1.3	6.3	6.3	6.3	9
2/12/38	8	2	8.87	1.3	6.4	6.4	6.3	....
2/19/38	–1	2.5	8.61	5.6	4.3	4.3	6.1	3
2/26/28	1.5	i–i	9.31	9.8	7.1	7.1	6.2	7
3/5/38	17.5	9	8.85	7.5	5.8	5.8	6.3	16
3/12/38	16	6.5	8.78	6.7	5.1	5.1	6.4	15
3/19/38	19	12	8.37	4.6	5.6	5.6	6.5	3
3/26/38	13	15	7.82	5.1	5.8	5.8	6.6	6
4/2/38	3.5	8	5.81	4.6	5.1	5.1	6.8	4
4/10/38	13	10	9.69	4.3	5.3	5.3	6.6	3
4/16/38	26	22	7.62	3.8	20.2	20.2	6.8	6
4/23/38	19	16	9.91	2.8	8.4	8.4	7.6	9
4/30/38	20	19	8.40	2.0	8.4	8.4	7.2	16
5/7/38	28.5	24.5	8.31	2.0	16.7	16.7	7.9	....
5/14/38	13	16	8.50	2.8	9.4	9.4	8 2	....
5/21/38	21	23	7.91	2.0	8.1	8.1	7.0	12
5/28/38	27	24.5	4.78	1.9	9.8	9.8	6.8	18
6/4/38	26	25	8.93	0	5.5	3.5	8.4	....
6/11/38	23	21	5.51	2.2	5.8	5.8	6.9	....
6/20/38	24	22	7.21	1.7	7.8	7.8	7.9	....
6/27/38	23	21	9.40	4.3	12.1	12.1	7.9	16
7/2/38	28.5	23	6.34	3.8	7.6	7.6	6.9	....
7/9/38	28	25	8.39	7.1	4.8	4.8	6.9	13
7/15/38	28	24	9.70	4.05	7.3	7.3	7.3	....
7/30/38	34	27	9.67	5.8	7.3	7.3	7.6	....
8/8/38	31	25	7.10	9.1	8.6	8.6	6.9	....
8/16/38	28.5	25	7.10	7.6	12.8	12.8	6.8	....
8/24/38	29.5	22	11.71	4.8	16.2	16.2	8.0	16
9/1/38	25	19	11.40	5.9	18.0	18.0	7.8	....
9/10/38	22	21	6.28	3.7	5.3	5.3	6.6	11
9/17/38	21	18	4.10	6.0	8.6	8.6	6.2	....
9/24/38	28	21	8.68	4.0	5.6	5.6	7.2	....
10/1/38	....	....	–drained–	....	....	....	....	....

*—impossible to measure (disk still visible at bottom); i—ice cover.

Station 4B—Physical and Chemical Factors

DATE	TEMPERATURE °C. AIR	TEMPERATURE °C. WATER	O_2 CC/L.	CO_2 CC/L. FREE	CO_2 CC/L. BOUND	CO_2 CC/L. ½BOUND	pH	TURBIDITY IN INCHES
10/10/37	20	15	13.70	1.2	27.6	27.6	8.3	6
10/16/37	15	10.5	16.93	0	52.6	17.2	8.4	6
10/23/37	8	10	11.81	0	26.8	26.0	8.5	6
10/30/37	24	14	13.81	0	19.6	16.4	9.6	7
11/6/37	16	9	19.60	0	42.5	32.8	9.6	5
11/13/37	14	9	22.21	0	18.1	1.5	9.6+	5
11/20/37	–6	0–1	8.08	0	37.0	27.2	9.2	4
11/27/37	12	5	11.86	2.6	10.6	10.6	8.0	6
12/4/37	3.5	1–1	15.36	0	47.4	43.4	9.0	5
12/18/37	0.5	1–1	11.25	1.4	11.1	11.1	7.0	7
12/31/37	10	8	9.18	1.3	18.3	18.3	7.3	8
1/8/38	–6	1–1	20.92	0	9.5	1.8	8.9	7
1/16/38	9	1–1	21.80	0	19.5	11.0	9.3	7
1/22/38	6	1–1	11.91	0	19.5	1.6	9.0	5
2/5/38	12	2–1	16.65	0	10.25	8.8	9.4	5
2/12/38	9	3	8.09	0	16.9	13.2	8.8	6
2/19/38	–1	3	12.27	3.8	11.6	11.6	8.2	5
2/26/38	1.5	1	12.38	6.6	15.4	15.4	7.1	9
3/5/38	18.5	12	13.60	4.6	15.4	15.4	8.0	6
3/12/38	17	7.5	11.98	0	21.0	19.8	8.4	9
3/19/38	17	12	14.23	0	12.9	6.8	9.0	3
3/26/38	13	15	13.97	0	13.9	13.9	9.0	7
4/2/38	3	9.5	7.30	2.2	12.8	12.8	8.0	6
4/10/38	19	9	12.58	3.5	11.8	11.8	7.8	5
4/16/38	25	20	11.20	0	12.6	3.1	9.2	9
4/23/38	19	16	12.20	0	21.7	1.0	9.6+	6
4/30/38	21	20	12.30	0	16.9	1.2	9.4	8
5/7/38	28	22	3.08	5.1	18.7	18.7	7.6	....*
5/14/38	13	16	6.08	5.6	16.8	16.8	7.4	21
5/21/38	21	24	8.98	0	16.4	0.3	9.4	5
5/28/38	28	27	6.90	0	25.8	25.8	9.6	19
6/4/38	26	25	10.72	0	13.6	4.3	9.6	8
6/11/38	23	22	10.20	0	17.6	0.2	9.5	5
6/27/37	23	24	14.21	0	40.5	0.1	9.5	5
6/20/38	26	22.5	13.30	0	18.4	7.8	9.5	4
7/2/38	28.2	23.2	10.81	0	23.5	12.1	9.6+	4
7/9/38	28	27	17.80	0	18.2	5.5	9.6+	4
7/15/38	28	28	22.80	0	20.0	2.0	9.5	....
7/30/38	34	28	25.00	0	21.1	2.7	9.6+	8
8/8/38	31.5	28	14.42	0	27.1	4.2	9.3	12
8/16/38	28.5	28	6.36	0	21.7	17.2	8.8	25
8/24/38	29	27	15.66	0	16.2	6.3	9.6+	19
9/1/38	25	22	7.72	0	18.2	11.7	8.8	22
9/10/38	22	22	6.59	3.0	12.5	12.5	8.1	7
9/17/38	21	20	7.80	0	19.3	10.1	7.1	....
9/24/38	28	20	9.41	0	12.9	12.9	8.4	....
10/1/38	....	....	–drained–		....	....	....	....
11/30/38	8	3	9.81	2.5	15.1	15.1	7.6	5
12/28/38	–7	1–1	15.80	0	29.8	4.3	9.4	8
1/29/39	6.5	3–1	19.81	0	8.9	3.9	9.6	4.5
2/25/39	–3	3–1	16.20	0	11.1	6.6	9.3	6
4/10/39	8	10	13.23	0	16.3	11.1	9.5	8

*—impossible to measure (disk still visible at bottom); 1—ice cover.

Some Works of Bartram, Daudin, Latreille, and Sonnini, and their Bearing upon North American Herpetological Nomenclature[1]

Francis Harper

The works here reviewed contain the type descriptions or other important information concerning a considerable number of North American amphibians and reptiles. Except in the case of Bartram, there has been much uncertainty as to the dates of publication, which are so important to the taxonomist and the bibliographer.

I shall first cite these works in the approximate sequence of publication, and thereafter discuss the evidence for some of the dates assigned. Various nomenclatural and taxonomic problems, including especially the original descriptions of the new North American species contained in these works, and the authorship of these descriptions, will also call for comment.

BARTRAM, WILLIAM. 1791—Travels through North & South Carolina, Georgia, East & West Florida, the Cherokee country, the extensive territories of the Muscogulges, or Creek Confederacy, and the country of the Chactaws; containing an account of the soil and natural productions of those regions, together with observations on the manners of the Indians. [First edition.] Philadelphia: pp. xxxiv + 522, 8 pl., 1 map.

BARTRAM, WILLIAM [sic]. 1799 (An vii)—Voyage dans les parties sud de l'Amérique septentrionale; savoir: les Carolines septentrionale et méridionale, la Georgie, les Florides orientale et occidentale, le pays des Cherokées, le vaste territoire des Muscogulges ou de la confédération Creek, et le pays des Chactaws; contenant des détails sur le sol et les productions naturelles de ces contrées, et des observations sur les moeurs des Sauvages qui les habitent. Imprimé à Philadelphie, en 1791, et à Londres, en 1792, et trad. de l'angl. par P. V. Benoist. Libraires Carteret et Brosson; Dugour et Durand.) Paris: vol. 1, pp. 1-457+[1], 3 pl.; vol. 2, pp. 1-436+[1], 1 pl., 1 map.

———1801 (An ix)—Voyage [etc.]. [Second Paris edition.] (Libraire Maradan.) Paris: vol. 1, pp. 1-457+[1], 3 pl., 1 map; vol. 2, pp. 1-436+[1], 1 pl. (Apparently identical with the 1799 edition, except for a different publisher or bookseller, and the transfer of the map from vol. 2 to vol. 1.)

DAUDIN, F. M. 1800 (An viii, An ix)—Histoire naturelle des Quadrupèdes ovipares. Livraisons 1 and 2. (Imprimerie Marchant et Cie; libraires Fuchs, Delalain fils, and Treuttel et Würtz.) Paris: 24 unnumbered pp., 12 pl.

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1 For advice on nomenclatural problems I am indebted to the late Dr. Witmer Stone, of the Academy of Natural Sciences of Philadelphia; for bibliographical assistance, to Miss Mary B. Cobb, librarian of the Boston Society of Natural History, and to Mrs. Gertrude D. Hess, assistant librarian of the American Philosophical Society.

Through the interest and generosity of Prof. Francis H. Herrick, of Western Reserve University, and of Dr. T. S. Palmer, of Washington, D. C., a portrait of Bosc is reproduced on page 707. It was secured in Paris by Prof. Herrick, but the work in which it was originally published has not been ascertained.

SONNINI, C. S., AND P. A. LATREILLE. 1801 (An x)—Histoire naturelle des Reptiles, avec figures dessinées d'après nature. (Chez Deterville.) Paris: vol. 1, pp. xx+280, 14 pl.; vol. 2, pp. 1-332, 21 pl.; vol. 3, pp. 1-335, 6 pl.; vol. 4, pp. 1-410, 13 pl.[2]

DAUDIN, F. M. 1801-1803 (An x, An xi)—Histoire naturelle, générale et particulière des Reptiles; ouvrage faisant suite à l'Histoire naturelle générale et particulière, composée par Leclerc de Buffon, et rédigée par C. S. Sonnini, membre de plusieurs sociétés savantes.[3] (Imprimerie de F. Dufart.) 8vo, Paris: vol. 1, pp. 1-384, 15 pl., 1801; vol. 2, pp. 1-432, 13 pl., 1801; vol. 3, pp. 1-452, 17 pl., 1802; vol. 4, pp. 1-397, 13 pl., 1802; vol. 5, pp. 1-365, 12 pl., 1 folding table, 1803; vol. 6, pp. 1-447, 10 pl., 1803; vol. 7, pp. 1-436, 12 pl., 1803; vol. 8, pp. 1-439, 8 pl., 1803.

———1802 (An xi)—Histoire naturelle des Rainettes, des Grenouilles et des Crapauds. (Imprimerie de Bertrandet; libraire Levrault.) Paris: 4to, pp. 1-108, 38 pl.; folio, pp. 1-71, 38 pl.[4]

The question of the dates of publication of the French works is complicated by the fact that in every case (except that of Daudin's "Quadrupèdes ovipares," which lacks a title-page) they are designated on the title-pages exclusively according to the calendar of the French Revolution. We have evidence that at least most of these publication dates are *bona fide*, and it is assumed that the remainder are likewise. It will be recalled that "An I" began on September 22, 1792. We are here concerned primarily with the following years:

"An viii" (September 23, 1799, to September 22, 1800)
"An ix" (September 23, 1800, to September 22, 1801)
"An x" (September 23, 1801, to September 22, 1802)
"An xi" (September 23, 1802, to September 23, 1803)

The apparently great rarity of three of the four original French works under discussion is probably largely responsible for the frequent incompleteness or inaccuracy of citations from them. Only Daudin's eight-volume work on

2 The Catalogue of the Library of the British Museum (p. 282, 1903) refers to the present work as forming part of the "suites à Buffon" and as being edited by Castel. While this information is doubtless correct, there appears to be no intrinsic evidence to that effect.

The present citation is from the set in the Library of Congress; the set at the Boston Society of Natural History has 20 plates in Volume 2 and 14 plates in Volume 4.

3 In Volumes 5-8 the subtitle reads as follows: "Ouvrage faisant suite aux Oeuvres de Leclerc de Buffon, et partie du Cours complet d'Histoire naturelle rédigé par C. S. Sonnini, membre de plusieurs sociétés savantes."

4 On page 2 the following formats and prices are listed:

In-4°. Papier d'Angoulême, gravures en noir,.....18 liv.
In-4°. Papier vélin, gravures en couleur, ...50 liv.
In-folio. Papier d'Angoulême, gravures en noir, ...25 liv.
In-folio. Papier vélin, gravures en couleur, ...75 liv.

Copies of the quarto edition are in the libraries of the Academy of Natural Sciences of Philadelphia, the American Philosophical Society, and the Boston Society of Natural History. The library of the United States National Museum contains the still rarer folio edition. The pagination is almost entirely different in the two editions. The quarto edition is the one commonly cited.

the "Reptiles" seems to be of reasonably wide availability. His "Quadrupèdes ovipares" was rarely cited from the very beginning, and by this time had been virtually consigned to the limbo of forgotten books. But sooner or later such of these works as contain new names of animals, in accord with the binary system, must be resurrected from the dust heaps.

In the following pages, detailed discussion of species will be largely restricted to those of North America.

This paper consists, for the most essential part, of a review of Daudin's work on North American herpetology. Besides undertaking the authorship of three separate works of his own (in ten volumes), he utilized Bartram's "Travels" in describing new species and had a personal share in the production of Sonnini and Latreille's "Reptiles"; and in all of these works North American species are included. Despite the several handicaps of living through the terror of the French Revolution, of suffering a nearly lifelong paralysis of his legs, and of passing away before the completion of his thirtieth year, Daudin succeeded in becoming, I believe, the most productive and very nearly the ablest herpetologist of his time.

Bartram's "Travels"

The first (Philadelphia) edition of this work is altogether too well known to require any comment as to its date of publication or its general contents. It may be said, however, that Bartram was the most notable of the eighteenth-century commentators on North American amphibians and reptiles, and that his account of the American Alligator is an immortal classic on that species.

Unfortunately Bartram applied a valid binominal name to only one of the reptiles he described. It therefore remained for Daudin and others to provide technical names for such of the remaining Bartramian species as had not already been named by Linnaeus or some of his contemporaries.

Since the pagination appears to be identical in both French editions of Bartram (1799 and 1801), it is practically impossible to determine which edition was utilized by Daudin for his references and quotations.

I have no definite information as to whether the first Paris edition (An VII) was published in 1798 or 1799, and whether the second edition (An IX) was published in 1800 or 1801; but they are generally cited as of 1799 and 1801, respectively. The exact dates are not particularly material, since no new species are named in these translations.

Testudo polyphaemus

The original reference of the Gopher Turtle has long been cited as *Testudo polyphemus* Daudin, Reptiles, vol. 2, p. 256; the date generally cited is 1802 or 1803, though now known to be 1801. Daudin's description is based upon Bartram's *Testudo polyphemus* (French editions, 1799 and 1801, vol. 1, pp. 55, 314-316). These editions follow the London edition of 1792 in spelling the specific name *polyphemus*. However, the original Philadelphia edition of 1791 (p. 18) has "*Testudo Polyphaemus*."

Why, it may be asked, is Daudin (1801), rather than Bartram (1791), commonly credited with the authorship of this species?

There seems to be a fairly widespread tendency among zoologists to exclude from consideration binominal names proposed in any one of the older works that also employs polynomial nomenclature to a greater or lesser extent. However, a careful scrutiny of the International Rules of Zoological Nomenclature (1910) fails to reveal any justification for such a policy. Under Article 25 of these Rules, any generic or specific name proposed since 1758 [up to January 1, 1931] has just two requirements for validity: (a) that this name has been published and accompanied by an indication, or a definition, or a description; and (b) that the author has applied the principles of binary nomenclature.

The names that Bartram applied to birds and other animals are, in part, binominal and, in part, polynomial; but in all cases, or at least in virtually all of them, he applied the principles of binary nomenclature (*cf.* Opinion 20, Intern. Comm. Zool. Nomencl.). Accordingly, any particular binominal name proposed by Bartram may be judged upon its individual merits, regardless of the fact that many of his other names are polynomial.

Testudo polyphaemus (emended to *polyphemus* after the first edition) is the only binominal name that Bartram proposed in herpetology. The original reference of this species may now be cited as follows: *Testudo Polyphaemus* Bartram, Travels, ed. 1, pp. 18, 182-183, 1791. In accordance with current generic concepts, the name will stand as *Gopherus polyphaemus* (Bartram).

Bartram includes "the great Land Tortoise called Gopher" in a manuscript account (Report to Dr. Fothergill, vol. 2, p. 51, 1775?; original in British Museum Herbarium) of the reptiles and amphibians of East Florida. In his "Travels" (1791) he records the species from the sand-hills south of the Altamaha River in Georgia (p. 18); in northeastern Florida, between the St. John's River and the Indian town of Cuscowilla (p. 182); and on the Georgia side of the lower Savannah River (p. 182). In Georgia Bartram seems to notice only the dens of the Gopher Turtle, while the description of the animal itself is included in an account of his travels through Florida, in the area between the present Palatka and Micanopy. More specifically, the habitat noticed by Bartram was apparently in the southeastern part of Alachua County, Florida, and this area may be regarded as the restricted type locality.

Daudin's "Histoire naturelle des Quadrupedes ovipares"

This uncompleted work work seems to be quite unfamiliar to herpetologists of the present day, both in America and abroad. Even C. D. Sherborn (Index Animalium, sect. 2, 1801-1850, pt. 1, p. xlii, 1922) seems not to have seen it, and assigns to it a date two years later than the actual date of publication. Günther (1858), Boulenger (1882), Cope (1889), Nieden (1923), and Stejneger and Barbour (1917, 1923, 1933, 1939) give no indication of acquaintance with its contents. It is especially important to us here as containing the hitherto overlooked type descriptions of three North American species of *Hyla;* one of these is a synonym, but the other two are valid to-day.

My first information as to the contents of the work came from two fortun-

ately detailed reviews in Millin's "Magasin encyclopédique" (6th year, vol. 4, no. 13, p. 131, Frimaire, An IX [Nov.-Dec., 1800], and 6th year, vol. 4, no. 16, p. 558, Nivose, An IX [Dec., 1800-Jan., 1801]). As originally projected, there were to have been 30 livraisons, each containing six plates and accompanying text. In its final form, according to the announcement, the work was to have been entitled "Traité élémentaire et complet de l'Histoire naturelle des Quadrupèdes ovipares," thus becoming a companion work to Daudin's "Traité d'Ornithologie" (Paris, 2 vols., 1800). Evidently no more than two livraisons were ever issued. These are of quarto size, and the 12 plates are the work of the artist Barraband.

Daudin presented livraison 1 to the Institute of France (Academy of Sciences) at its seance of 26 Fructidor, An VIII [September 13, 1800], and livraison 2 at the seance of 21 Brumaire, An IX [November 12, 1800] (Institut de France, Acad. Sci., Procès-verbeaux Seances, vol. 2 (An VIII-XI), pp. 225, 267, 1912). Furthermore, in Sonnini and Latreille (Reptiles, vol. 2, pp. 170, 173, 175, 178, 179, 1801) we find references to livraisons 1 and 2 of Daudin's "Quadrupèdes ovipares." These facts, in connection with the dates of the reviews, virtually fix the date of publication of livraison 1 as early September, 1800, and of livraison 2 as early November, 1800.

The six plates of livraison 1, according to the reviewer, are the following: 1, 2, *Hyla bicolor;* 3, *Hyla frontalis;* 4, *Hyla tinctoria;* 5, *Hyla femoralis, Hyla squirella;* 6, *Hyla rubra.* Those of livraison 2 are: 1, *Hyla viridis;* 2, *Hyla boans;* 3, *Hyla venulosa;* 4, *Hyla lactea, Hyla hypochondrialis;* 5, *Hyla lateralis, Hyla bilineata;* 6, *Hyla marmorata.* (In future citations of these originally unnumbered plates, it will be well to assign to them the numbers 1 to 12, in the order in which they are here listed.)

The reviewer states (p. 558) that the author gives for each species a Latin description, synonymy, characters, habitat, and sometimes varieties.

It is significant that these very species are described in the early pages of Daudin's "Histoire naturelle des Rainettes, des Grenouilles et des Crapauds" (1802). The latter also is of quarto size, and the plates are likewise by Barraband. Thus I was led to suspect that the "Quadrupèdes ovipares" was simply a forerunner of the "Rainettes," and was discontinued, for some unknown reason, in favor of the latter after only two livraisons were issued.[5] But the later work never attained the ambitious proportions planned for the original work.

This much, and more, had been written concerning the present work, when, through the great courtesy and kindness of Mlle. G. Dollfus, Assistant Librarian of the Muséum National d'Histoire Naturelle, Paris (*in litt.*, August 28, 1938, and October 15, 1938), I received some extraordinarily interesting additional information concerning it. The Paris Museum itself,

5 In reviewing the "Rainettes," Millin remarks (Mag. Encycl., 7th year, vol. 5, pp. 272-273, 1803): "We announced, a few years ago, the first sample ['essai'—the 'Quadrupèdes ovipares'] that Citizen Daudin gave of this work which appears to-day in complete form."

and even the Institute of France, now possess only livraison 1! Was an effort made by Daudin to recall and destroy both livraisons, while substituting for them the "Rainettes"? Even Volume 4 of the first edition of Holbrook's North American Herpetology (1840), which seems to have suffered such a fate (*cf.* Gill, Science, n. s., vol. 17, no. 440, pp. 911-912, 1903), is possibly not quite so excessively rare as Daudin's "Quadrupèdes ovipares."

Some of the information so kindly furnished by Mlle. Dollfus may be rather freely translated as follows:

Millin's description (in the review) is the exact and complete transcription of the cover of livraison 1.[6] I suppose, therefore, that the description of livraison 2 in Millin can be considered a textual copy of the cover of that livraison.

At the Museum we possess only livraison 1, which, moreover, is very rare; it comes from the collection of J. B. Huzard, Academician (1755-1838).

I shall transcribe for you a manuscript note (perhaps by M. Huzard) which is at the head of our copy and gives some interesting details:

"This livraison 1 of the 'Histoire naturelle des Quadrupèdes ovipares' by F. M. Daudin is the only one, I believe, that has appeared of this work, which was interrupted by various commercial circumstances. It would have been more extensive and more complete than the 'Histoire naturelle des Rainettes' and would have contained 150 plates. The text and the plates would have been in part the same as those of the 'Rainettes,' but arranged in a different order.

"This livraison 1, on vellum paper, is a sample ['essai'], the text is of a smaller format than the plates, there is neither title, nor name of author ['signature'], nor pagination to the signature ['feuille'] and a half of which it is composed, and the six plates are not numbered.

"The dedication to M. de Lacépède is the same as that of the 'Rainettes.' The text corresponds to pages 22-26, 18-19, and 26-27, and the plates to Nos. 5, 8, 3, 9, and 6 of the latter work; the composition has been done over ['remanié'], the order has been changed, and the plates have been retouched; that which corresponds to plate 9 has been reëngraved and it includes only two frogs; the 'rainette orangée' [*Hyla aurantiaca*] is not there.

"On the envelope are found the title, the conditions of subscription, and the names of the booksellers: Fuchs and Delalain fils, and Treuttel and Würtz. One reads at the bottom of the back of the title: 'De l'Imprimerie Marchant et Cie, rue du Pont de Lodi,' without date, but about 1803.

"I have not found the work indicated in any bibliography, nor in any biography. My friend Bosc, who was associated with M. Daudin, assured me that there was no necessity for it ['il n'avait pas eu lieu'] and that the materials had served for the 'Rainettes,' with which Levrault alone was charged, and consequently this sample had appeared before the 'Rainettes'."

After quoting Huzard's note, as given above, Mlle. Dollfus adds that she has verified on the two works (the "Quadrupèdes ovipares" and the "Rainettes") the exactitude of M. Huzard's comparison. She also states that two species concerning which I had particularly inquired are introduced as "*Hyla squirella* Bosc" and "*Hyla femoralis* Bosc."

Thus these two names are here, in the original description, quite definitely credited to Bosc, but exceedingly few subsequent works recognize the fact.

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6 The title thus cited by Millin is: "Histoire naturelle des Quadrupèdes ovipares; par F. M. Daudin, membre des sociétés d'histoire naturelle et philomatique de Paris. Avec des gravures faites et enluminées sur les dessins d'après nature, par J. Barraband. Première livraison."

Indeed, we might have concluded, solely on the basis of the next three publications of these names (1801, 1802, and 1803), that while Bosc was evidently ethically responsible, Daudin was the technically responsible author of the names, or at least a joint author.[7]

We had already known that Bosc described and named these two species in a manuscript, which Daudin evidently copied. For in his "Reptiles" (vol. 8, pp. 32, 34, 1803) Daudin cites the following: "*Hyla femoralis*. Bosc, Note manuscrite communiquée" and "Hyla *squirella*. Bosc, Note manuscrite communiquée." Moreover, Bosc himself writes (Nouv. Dict. Hist. Nat., ed. 1, vol. 19, p. 185, 1803) concerning *femoralis:* "It is found in North America, where I have described and drawn it." But neither in the "Reptiles" nor elsewhere does Daudin make any reference to the original publication of these species. For some reason or other, he seems never to have cited the "Quadrupèdes ovipares" in any of his later works. The original references may now be cited as follows: *Hyla squirella* Bosc, in Daudin, Histoire naturelle des Quadrupèdes ovipares, livr. 1, p. [9], pl. [5], lower fig., 1800 (la Caroline"); and *Hyla femoralis* Bosc, in Daudin, Histoire naturelle des Quadrupèdes ovipares, livr. 1, p. [10], pl. [5], upper fig., 1800 ("la Caroline"). These descriptions antedate by about a year those that Daudin furnished for Sonnini and Latreille's "Reptiles" (vol. 2, p. 181, 1801). On the page just cited we read concerning *femoralis:* "It has been discovered and described by Bosc, in Carolina."

Hyla lateralis is the third North American species here introduced (on p. [21]), but it is a synonym of *Hyla cinerea* (*Calamita cinereus* Schneider, 1799). It is evident that *Hyla lateralis,* as far as the authorship of the name is concerned, belongs in approximately the same category as *Hyla ocularis,* which is discussed more fully in the review of Sonnini and Latreille's "Reptiles." Here, in the original publication, Daudin omits to credit *lateralis* to Bosc; and since no author's name is supplied, one might readily conclude that Daudin himself is the author. However, in a later work (Reptiles, vol. 8, p. 27, 1803) he gives the following reference: "*Hyla lateralis*. Bosc, Note manuscrite communiquée." While the authorship of this synonym is comparatively immaterial, it is perhaps best to credit the name to Bosc and Daudin jointly, as I suggest in the case of *H. ocularis.* The type locality of *lateralis* is "environs de Charlestown," South Carolina.

H. Cloquet (in Dict. Sci. Nat., vol. 44, pp. 395-396, 1826) may have been familiar with the "Quadrupèdes ovipares," for he credits *lateralis, femoralis,* and *squirella* to Bosc. E. Desm[arest?] (in Guerin, Dict. Pitt. Hist. Nat., vol. 8, p. 444, 1839) does likewise.

The authority for *Hyla frontalis* and *Hyla hypochondrialis* will be Daudin (1800). Sherborn cites these two names as of Latreille (1801). In Latreille's own work (Reptiles, vol. 2, pp. 178, 179, 1801) we find more or less plain

7 Sherborn (Index Animalium 1801-1850, p. 2345, 1926, and p. 6123, 1931) credits *femoralis* to Daudin and *squirella* to Latreille, while Stejneger and Barbour (Check List N. Am. Amphibians Reptiles, ed. 4, p. 40, 1939) credit both names to Latreille.

indication of Daudin's prior description of both species. The type locality of each is "Surinam."

A number of the names in the "Quadrupèdes ovipares" appear to represent generic transfers: *Hyla bicolor*=*Rana bicolor* Boddaert (1772); *Hyla tinctoria*=*Rana tinctoria* Cuvier (1798); *Hyla boans*=*Rana boans* Linnaeus (1758); *Hyla venulosa*=*Rana venulosa* Laurenti (1768); *Hyla marmota*=*Bufo marmoratus* Laurenti (1768).

Up to this point I had concluded that there was no copy of the "Quadrupèdes ovipares" in America, and was convinced of the need of securing a photostat copy from Paris. However, in September, 1938, while looking through the card catalogue of the library of the American Philosophical Society, I was rather startled to notice that Daudin's "Rainettes" was credited with 24 more pages and 12 more plates than was proper. Half suspecting what proved to be the case, I hastily sought this copy of the "Rainettes," and realized at once that the additional 24 pages, bound at the end of the volume, constituted the long-buried "Quadrupèdes ovipares"! Lacking a title-page, this work had apparently reposed in the Society's library, unrecognized and uncatalogued (except as so many extra pages and plates of the "Rainettes") for 101 years, or since 1837. At some time within that period it had become bound up with the "Rainettes."

The records of the library show that this copy of the "Rainettes" was an item (listed at 14 francs) in an invoice of books purchased by George Ord in Paris and shipped via the "Francois 1er" in February, 1829. The books were "examined" by the Library Committee (consisting of George Ord, Isaac Hays, and Charles Pickering) in April, 1837, and apparently they formally passed into the possession of the American Philosophical Society at that time. This lot of books is referred to as "the Ord purchase." There is apparently nothing in the records to distinguish the two livraisons of the "Quadrupèdes ovipares." Perhaps it is safe to assume that they accompanied the copy of the "Rainettes" in the shipment of 1829, and had ever since been considered a part of the latter work.

The 12 colored plates of the "Quadrupèdes ovipares" had been inserted in the bound volume alongside their uncolored counterparts belonging to this copy of the "Rainettes." A collation, by the Assistant Librarian of the American Philosophical Society and myself, of this bound volume with the copy of the "Rainettes" in the library of the Academy of Natural Sciences of Philadelphia, enabled us to distinguish the plates belonging to each of the two works. The description of the copy of livraison 1 of the "Quadrupèdes ovipares" in the Paris Museum, contained in a letter from Mlle. Dollfus (as already mentioned), greatly facilitated our task. This was in preparation for rebinding the two works separately (which has now been effected).

An interesting result of the collation was the discovery that some of the plates in the two works are identical and interchangeable. This doubtless explains the fact that some of the colored plates in the copy of the "Rainettes" belonging to the Academy of Natural Sciences (and some of the uncolored ones in the Philosophical Society's copy) have no number printed on them;

they were evidently "left-overs" from the stock of plates prepared for the "Quadrupèdes ovipares," none of which bear a number.

Since the pages in the last-mentioned work had likewise been left unnumbered, it seemed desirable to assign numbers to them. No title-page having been printed, the dedication page (identical in wording with, but slightly different in typography from, the dedication to Lacépède in the "Rainettes") is the first one that can be numbered. The dedication page in the "Rainettes" is included in the Arabic pagination, and it seemed best to follow the same plan in the "Quadrupèdes ovipares." Thus the pages on which the 14 species of *Hyla* in livraisons 1 and 2 are introduced may be listed as follows: *bicolor*, 3; *frontalis*, 5; *tinctoria*, 7; *squirella*, 9; *femoralis*, 10; *rubra*, 11; *viridis*, 13; *boans*, 15; *venulosa*, 17; *lactea*, 19; *hypochondrialis*, 20; *lateralis*, 21; *bilineata*, 22; *marmorata*, 23.

Daudin here credits the name *Hyla bilineata* to Van-Ernest, and states that he received from the latter a description and a drawing of the species. Thus Van-Ernest must be considered the author of *bilineata*, although the fact is not apparent from any later work that I have seen. The type locality is "les bois de l'île de Java."

The excessive rarity of the "Quadrupèdes ovipares," and the obscurity in which it has so long reposed, are perhaps sufficient justification for the length of the foregoing comments.

Sonnini and Latreille's "Histoire naturelle des Reptiles"

The next work to be considered, in chronological sequence, is that of Sonnini and Latreille.[8] This small four-volume work is apparently identical in format with numerous other volumes in the "suites à Buffon" (including works by de Tigny, Brongniart, Lamarck, Mirbel, Bosc, Patrin, and Bloch). Latreille is stated to be the author of all parts of the present work except the "discours préliminaire" [vol. 1, pp. iii-xxii] and the account of the salamanders [vol. 2, pp. 188-264], with both of which Sonnini is credited. Several salamanders are also discussed in the "Éclaircissemens et Additions" (vol. 4, pp. 239-315), but there is good reason to believe that Latreille is responsible for all matter in the "Éclaircissemens et Additions." References to Latreille's part of this work are commonly cited as "Latreille, Histoire naturelle des Reptiles," but it would be more accurate to write "Latreille, in Sonnini and Latreille, Histoire naturelle des Reptiles."

The date on the title-page of each of the four volumes is "An X" [September, 1801, to September, 1802]. But so far the various authorities have not reached an agreement as to the part of "An X" in which the actual date of publication fell. For example, the Catalogue of the Library of the British

8 I know of only two sets of the original edition in America—one in the Library of Congress, the other in the Boston Society of Natural History. It must be similarly rare in Europe, for such monographers as Günther, Boulenger, and Nieden do not seem to cite it. The Academy of Natural Sciences of Philadelphia has only the Roret edition of 1830, which is almost but not quite identical with the original Deterville edition of 1801.

Museum (p. 282, 1903) gives the date as 1802, and Sherborn (Index Animalium 1801-1850) cites various names from this work as of 1801, while Stejneger and Barbour, in successive editions of their "Check List of North American Amphibians and Reptiles" (1917, 1923, 1933, 1939) have consistently cited the work as of 1802. In Daudin, however, we find incontrovertible evidence as to the year of publication. As we shall see later, the first two volumes of his own "Histoire naturelle des Reptiles" were published not later than December, 1801. In Volume 1, page 339, he refers to the "méthode de Latreille (1801), . . . Histoire naturelle des Reptiles, edit. de Buffon, par Déterville." Furthermore, his Volume 2 contains numerous page references to Latreille, whose work, therefore, unquestionably had prior publication. In view of the probable length of time required to put Daudin's Volumes 1 and 2 through the press, Sonnini and Latreille's work must have appeared extremely early in "An X"—say September or (at the latest) October, 1801.

This work includes the descriptions of a number of new species, ostensibly by Latreille. In a large proportion of these cases, however, there is a knotty problem as to authorship, which seems to have been largely overlooked by later investigators. Latreille gives no authorities for names in the headings, and no lists of references or so-called "synonymies." As more information on the problem comes to light, it becomes more and more certain that Daudin was the actual though largely unacknowledged author of some of the new species. In several cases it is also evident that Bosc is joint author with Daudin.

As far as I am aware, nothing has ever appeared in print to explain why no unequivocal acknowledgment was made of Daudin's share in the production of Sonnini and Latreille's work, or how he came to publish separately and at about the same period, under his own name, the three other works discussed here. However, Dr. Leonhard Stejneger (*in litt.*, December 9, 1937) has informed me of a sort of tradition that "while the two [Latreille and Daudin] were previously good friends, they had a falling out when each undertook the 'Histoire Naturelle' for the rival publishing firms."

In his "Rainettes" (p. 12, 1802), Daudin makes the very definite claim that he prepared the descriptions of certain species in the work of Latreille. His statement on this point (dated February 20, 1802) is worth quoting in full, more especially in view of the rarity of the work in which it appears. A translation follows:

"All the batrachians of which I have already given an abridged description in the *Histoire Naturelle des Reptiles, by Latreille*, will be indicated in this new work by an asterisk following the specific Latin name. I ought to observe, however, that the following descriptions include numerous additions and some corrections.

"Some of the drawings which are used in the present work, and which were made by Barrabaand, have been utilized by M. Desève, who has merely reduced them and published them by error *under his name*, in the little edition of the Histoire Naturelle des Reptiles, on which I have worked with my friend Latreille, for the Déterville publishing firm."

This statement indicates a sort of piracy of illustrations in addition to the partly unacknowledged use of Daudin's material in the text. A comparison

of the works in question shows indeed that certain drawings credited to Desève in Sonnini and Latreille's work are merely reduced copies of the Barraband drawings that were reproduced in Daudin's "Quadrupèdes ovipares" of 1800, or bear a conspicuous similarity to still other plates in Daudin's "Rainettes" of 1802. The original drawings or the proofs of the plates may have been somehow available to Desève in advance of their publication.

The species that Daudin marks with an asterisk in the "Rainettes" number 38 all told. These are included in Sonnini and Latreille's Volume 2, and in that part of it for which Latreille assumed sole responsibility. Among them, the following six species had been first published in Daudin's "Quadrupèdes ovipares" of 1800: *Hyla frontalis, H. femoralis, H. squirella, H. hypochondrialis, H. lateralis,* and *H. bilineata.* Various other names had had still earlier publication by Linnaeus, Laurenti, and others. We need be concerned for the moment only with those species of Hylidae, Ranidae, and Bufonidae whose original descriptions are published in Latreille's present work and whose names are marked with an asterisk in the "Rainettes." (There will be subsequent discussion of an additional frog and certain salamanders and reptiles whose names were likewise first published here.) The following list includes the names of the new frogs and toads, together with the pages in Volume 2 on which they are introduced, their ranges as originally stated, and indications (if any) of the authorship of their names.

Bufo Roeselii, p. 108: southern Europe and Germany. (No mention of Daudin.)

Bufo gutturosus, p. 135: range unknown. (No mention of Daudin.)

Rana grunniens, p. 155: Florida and the coasts of Carolina. (No mention of Daudin.)

Rana rubella [=*Hyla rubella* in the "Rainettes"], p. 160: range unknown. ("This description is from Citizen Daudin.")

Hyla intermixta,[9] p. 182: Surinam. ("Citizen Daudin has communicated to me his observations on this species.")

Hyla verrucosa, p. 186: range unknown. ("Citizen Daudin has made this description.")

Hyla ocularis, p. 187: Carolina. (No mention of Daudin.)

At this period of zoological history it was by no means invariably customary to label new species as such. Certainly the new species in the present work are not so indicated (with one exception); nor is there any very definite or orderly citation of authorities for names, whether new or old, although the original author may be mentioned occasionally in the discussion of a species. The whole treatment here is considerably less professional than that in Daudin's several works. The latter are at least provided with definite references to previous literature.

In determining which species are new in the present work, my dependence

9 It is not actually this name, but an equivalent of it, that is starred in the "Rainettes," as will be shown presently.

has been chiefly on other sources of information. On the basis of Daudin's claim, already quoted, it would seem reasonable to regard him as the actual author of at least most of the seven new names listed above, although they were published either with none too explicit assignment of the credit to him (three cases) or with no acknowledgment at all (four cases). If Daudin's claim had been improper or unjustified, would not Latreille have disputed it at some time or other during the approximately thirty remaining years of his life? Can his silence be interpreted otherwise than as acquiescence?[10]

Bosc (in Nouv. Dict. Hist. Nat., ed. 1, vol. 19, p. 182, 1803) remarks that the majority of the species of *Hyla* included in Sonnini and Latreille's work were discovered in the collections of Paris by Daudin. Furthermore, we have the authoritative testimony of Cuvier (in Michaud, Biographie universelle, nouv. ed., vol. 10, p. 161, 1855?) that Daudin "had inserted some articles in the Buffon of M. Castel for the part of the reptiles" (*i. e.*, in Sonnini and Latreille's work).

Article 21 of the International Rules of Zoological Nomenclature states that "the author of a scientific name is that person who first publishes the name in connection with an indication, a definition, or a description, unless it is clear from the contents of the publication that some other person is responsible for said name and its indication, definition, or description." By the strictest possible interpretation of this somewhat ambiguous rule it might appear necessary to credit Latreille with most of the names under discussion, quite regardless of any subsequent evidence that he neither originated the names nor prepared the descriptions. But surely the International Rules would fall short of their purposes if they were so formulated or could be so construed as to deny the credit of authorship to those who are really responsible for the names and the descriptions of new species. For the admission of *post facto* evidence, there is a precedent in the case of the new names published in the "Adumbratiunculae" of Vroeg's Catalogue (1764); although there is nothing in this publication to show that Pallas was the author of the new names, he is currently given that credit on the basis of subsequent evidence (*cf.* Richmond, Smiths. Misc. Coll., vol. 47, pp. 342-347, 1905, and Stone, The Auk, vol. 29, pp. 205-208, 1912). There is also the case of J. E. Gray, who is commonly credited with the authorship of the Synopsis of the Mammalia (excepting Ruminantia) in Griffith's edition of Cuvier's "Animal Kingdom," vol. 5, 1827, including the new names proposed therein, although there is apparently nothing in the volume itself to indicate Gray's authorship (*cf.* Catalogue Library Brit. Mus., vol. 1, p. 410, 1903).

With such precedents, I had already concluded that Daudin was entitled to be considered the author of certain of the names under discussion, when the

10 It may be well to recall that this was more than a hundred years before the adoption of the International Rules of Zoological Nomenclature. In those days there was evidently far less emphasis on the authorship of names, and on the credit for such authorship, than nowadays. Even half a century after the publication of the present work, reasonable uniformity in nomenclatural practice was still rather far from having been attained (*cf.* I. Geoffroy Saint-Hilaire, Cat. méthod. Coll. Mammifères Oiseaux, pp. x-xv, 1851).

invincible additional evidence of his "Quadrupèdes ovipares" came to hand. As already noted, this work includes six of the species marked with an asterisk in the "Rainettes." It is obvious that the law of priority was not so fully recognized nor so commonly invoked in those days as now. Nevertheless it is strange that Daudin did not in the present instance cite the publication of his names of 1800; it is equally strange that he makes no reference to the "Quadrupèdes ovipares" in any of his other and later works. Was it possibly injured pride that deterred this young man in his twenties from referring to an ambitious work that had had to be abandoned before its completion?

Of the seven names listed above, whose authorship is in question, Sherborn (Index Animalium 1801-1850) credits the following to Latreille: *Bufo roeselii, Bufo gutturosus* (this being also cited from Daudin's "Rainettes"), *Hyla intermixta,* and *Hyla ocularis.* However, on Daudin's testimony (supported at least to a certain extent by that of Bosc and of Cuvier), Latreille is not the author of these names. The first two may at once be credited to "Daudin, in Sonnini and Latreille," and need not be discussed further here. Sherborn (*op. cit.,* p. 6866) is correct in crediting *Hyla verrucosa* to "Daudin in Latreille," although it would be somewhat more accurate to write "Daudin, in Sonnini and Latreille."

Sherborn (*op. cit.,* p. 5576) cites *Rana rubella* from "Daudin in Latreille" (1801) and *Hyla rubella* from "Daudin, N. H. Rainettes" (1802). The context in the latter work indicates that "*Hyla*" is a *lapsus calami* for "*Rana.*" In any event, Daudin is properly credited with the authorship of *rubella.*

The case of *Hyla intermixta* is a peculiar one. In Daudin's "Rainettes" this same frog, from Surinam, is renamed *Hyla variegata* (p. 20), with an asterisk affixed to indicate that Daudin provided the description in Sonnini and Latreille. However, there is no *Hyla variegata* in Sonnini and Latreille, and *Hyla intermixta* is obviously the species that Daudin intended to designate. In fact, we read concerning it on page 182 of Sonnini and Latreille's Volume 2: "Cette espèce, sur laquelle le citoyen Daudin m'a communiqué ses observations . . ." Daudin may therefore be considered the author of *Hyla intermixta* (1801), of which *Hyla variegata* Daudin (1802) is a pure synonym. Curiously enough, Daudin attempts to employ the name *Hyla intermixta* in the "Rainettes" (p. 21; without an asterisk) for a different frog of unknown origin. This use of the name in 1802 is naturally invalid, since it is a homonym (though not a synonym) of the *Hyla intermixta* of 1801.

Rana grunniens and *Hyla ocularis* will require somewhat more extended discussion.

Rana grunniens

William Bartram writes (Travels, pp. 276-277, 1791; French editions, vol. 2, pp. 19-20, 1799 and 1801): "(1) The largest frog known in Florida and on the sea coast of Carolina, is about eight or nine inches in length from the nose to the extremity of the toes; they are of a dusky brown or black colour on the upper side, and their belly or under side white, spotted and clouded with dusky spots of various size and figure; their legs and thighs also are variegated with transverse ringlets, of dark brown or black, and [they] are

yellow and green about their mouth and lips: they live in wet swamps and marshes, on the shores of large rivers and lakes; their voice is loud and hideous, greatly resembling the grunting of a swine, but not near as loud as the voice of the bull frog of Virginia and Pennsylvania, neither do they arrive to half their size, the bull frog being frequently eighteen inches in length, and their roaring as loud as that of a bull."

This frog, to which Bartram applies no technical name, is beyond any question the Southern Bullfrog, currently known as *Rana grylio* Stejneger.

In Sonnini and Latreille (vol. 2, pp. 155-156) we find the original technical description of *Rana grunniens* (la grenouille grognante), of which the following is a translation:

"The upper part of its body is brown or black, and the lower part is white, with shades and spots more or less brown and varied in form.

"It is eight to nine inches in length from the tip of the nose to the extremity of the hind feet; and it is, according to Bartram, the largest frog that has been seen in Florida and on the coasts of Carolina.

"Its legs have transverse blackish bands; the area about the mouth and the lips is yellow.

"Bartram discovered this frog in the lakes and the large rivers of the southern parts of North America; its weak ["foible"—mistake in translation of "loud"] and disagreeable voice resembles the grunting of a hog. Two individuals of this species, placed in the Paris Museum of Natural History, have a streak or several elongated spots of yellowish behind the eye."

It will be observed that all but the last sentence of this description is an almost literal translation from Bartram. The final sentence, mentioning an additional character evident in two specimens in the Paris Museum, of unspecified provenance, can not obscure the fact that Bartram's frog is clearly the type of *Rana grunniens*.

This is one of the species for which Daudin (Rainettes, p. 12, 1802) claims the credit of authorship. He redescribes it on pages 65-66 of the work just mentioned. This redescription is based primarily upon the two Paris specimens, one of which is represented in Plate 21. Daudin then adds Bartram's account, and remarks that the latter's frog is undoubtedly the same species as *R. grunniens*. This treatment, in shifting the major emphasis from Bartram's account to the Paris specimens (still of unknown origin), can scarcely affect the application of the name in the original description.

In his "Reptiles" (vol. 8, p. 127, 1803) Daudin repeats the description published in the "Rainettes," and gives the following references: *"La grenouille grognante*. Daudin, Hist. nat. des reptiles par Latreille, in-18, tom. II, p. 155. —*Idem*. Daudin, Hist. nat. des rainettes, des grenouilles, etc. in-4°, p. 65, no. 13, pl. xxi.—Bartram, Voyage en Caroline et en Floride, in-8°, tom. II, chap. 10."

Merrem (Tentamen Syst. Amphibiorum, p. 174, 1820) says of *Rana grunniens:* "Habitat in America." Even if it were necessary to consider that the original description was based upon a composite species, this action of apparently the "first reviser" in restricting the name to the American component would be decisive.

On the other hand, Duméril and Bibron (Erpétologie générale, vol. 8, pp. 380-383, 1841) attempt to restrict the name *Rana grunniens* Daudin to the individual described and figured in the "Rainettes" (p. 65, pl. 21); this they *suppose* to have come from Java. They overlook the fact that the original description in Sonnini and Latreille (vol. 2, p. 155) applies primarily to the American species, and that Merrem has restricted the name *grunniens* to that species. Apparently all later authors, without referring to the original description in Sonnini and Latreille, follow Duméril and Bibron in applying the name to some East Indian species; among these may be mentioned Günther (Cat. Batrachia Salientia Brit. Mus., p. 10, 1858), Boulenger (Cat. Batrachia Salientia Brit. Mus., ed. 2, pp. 23-24, 1882), and Van Kampen (Amphibia Indo-Australian Archipelago, pp. 172-173, 1923). This action is clearly erroneous and invalid.

Thus Daudin's name is available for the Southern Bullfrog, and the original reference may be cited as follows: *Rana grunniens* Daudin, in Sonnini and Latreille, Histoire naturelle des Reptiles, vol. 2, p. 155, 1801 (based upon "the largest frog known in Florida and on the sea coast of Carolina," of William Bartram (Travels, pp. 276-277, 1791; or vol. 2, chap. 10, [p. 19,] of the French editions of 1799 and 1801). *Rana grylio* Stejneger (Proc. U. S. Nat. Mus., vol. 24, p. 212, 1901) becomes a synonym.

Sherborn (Index Animalium 1801-1850, p. 2845, 1926) overlooks the first publication of *Rana grunniens*, and cites it from Daudin's "Rainettes" (1802).

No type locality was specified in the original description of *grunniens*, but the range was given as "la Floride et . . . les côtes de la Caroline." There have been no subsequent records from either of the Carolinas.

In an earlier, unpublished account of the frogs of East Florida (Report to Dr. Fothergill, MS, vol. 2, p. 59, 1775?), Bartram mentions the occurrence of the present species "in the wet marshes of St. Johns River & other great waters." Since Bartram spent considerable time at Lake George on the St. John's River, Florida, I venture to suggest that as the restricted type locality. I heard the characteristic voice of the species on Lake George on June 29, 1939.

The task of providing another name for the East Indian species that has masqueraded for nearly a century under the name of *Rana grunniens* Daudin is one that is best left to some student of Malayan herpetology.

Hyla ocularis

We have already seen, in the discussion of Daudin's "Quadrupèdes ovipares," that Bosc is the responsible and valid author of *Hyla femoralis* and *Hyla squirella* — species long credited to Latreille. *Hyla ocularis* is one of several additional species with which the name of Bosc is intimately associated. Therefore the present seems an opportune occasion for saying a few words concerning this accomplished and enthusiastic French naturalist.

In the collection, description, and naming of new species of North American amphibians and reptiles at this period, Louis Augustin Guillaume Bosc (1759-1828) played an extremely important rôle, and yet one that was most

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Mort à Paris le 10 Juillet 1828

remarkable for its modesty. It would be impossible to leave him out of any discussion of Daudin's work on North American forms.

Bosc spent a considerable period in the vicinity of Charleston, S. C., beginning in 1796 and extending at least to 1798. (Various authorities sadly disagree on these dates, and especially on the year of his return to France.) While in this country, he amassed immense materials in natural history, and even before his return to France, he transmitted all of his herpetological and ichthyological drawings and descriptions to Lacépède, at the same time expressing a desire to have them published in the natural history work on which Lacépède was then engaged (*cf.* Lacépède, Histoire naturelle des Poissons, vol. 2, pp. 109, 493, 1800).

Bosc's ornithological material was turned over to Daudin (*cf.* Cuvier, Mém. Acad. Roy. Sci. Inst. France, vol. 10, p. cciv, 1831), who seems to have been eventually designated as the chief beneficiary of the herpetological material as well (*cf.* Daudin, Reptiles, vol. 2, p. 153, 1801, and vol. 5, p. 6, 1803). Within a few years after Bosc's return, there were published in Paris, in rapid succession, the several important works — by his friends or associates, Daudin, Latreille, and Sonnini — that form the major subject of the present paper.

The descriptions of new North American amphibians and reptiles in these works were based largely upon Bosc's materials (including specimens, drawings, and descriptions with names). Bosc made such substantial contributions to Daudin's work that in some cases he stands as the sole author of new species, while in other cases we can hardly do less than credit him with joint authorship. There were also certain specimens of new species contributed by those distinguished French naturalist-explorers, Palisot de Beauvois (1752-1820) and André Michaux (1746-1802). Three other new species named by Daudin were based upon the accounts in a French edition of Bartram's "Travels" (1799 or 1801).

As pointed out above, *Hyla ocularis* is one of the 38 species for whose description in Sonnini and Latreille's work Daudin claims responsibility. This is the original description, in 1801. In his third and final description of the species, Daudin (Reptiles, vol. 8, p. 68, 1803) includes the following references: "*La raine oculaire*. Daudin, Hist. nat. des reptiles par Latreille, in-18, tom. II, p. 187. . . . *Hyla ocularis*. Bosc, Note manuscrite communiquée." He remarks further (p. 69): "The description of this *Hyla* has been communicated to me with a specimen and a drawing by Bosc."

It may be remarked here that Merrem (Tentamen Syst. Amphibiorum, p. 172bis, 1820) alone, among the early authors, credits the name *ocularis* to Latreille, while Sherborn (Index Animalium 1801-1850, p. 4538, 1929) is the only recent one to do so.

It is evident that Bosc furnished both the name and a description of *Hyla ocularis*. Daudin must have utilized this description at least in part, while adding a few details of his own (in respect to length). Under these circumstances it seems entirely proper to credit Bosc and Daudin with joint responsi-

bility for the new species, and to cite the original reference as follows: *Hyla ocularis* Bosc and Daudin, in Sonnini and Latreille, Histoire naturelle des Reptiles, vol. 2, p. 187, 1801. In another paper (Am. Midl. Naturalist, vol. 22, no. 1, pp. 137-140, 1939) I have sought to show the identity of this species with the one recently known as *Pseudacris ocularis* (Holbrook).

For *Hyla ocularis*, and for most of the other Boscian species as well, no more definite type locality was originally indicated than "la Caroline." Bosc's general headquarters were at Charleston, S. C., or vicinity; his dwelling place, for a time at least, was at Michaux's botanical garden 10 miles north of the city. He is said to have traveled about the country on numerous excursions, but authentic information on the extent of those excursions is meager or lacking. Three of his new fishes (*Raia eglanteria* Bosc, *Blennius bosquianus* Lacépède, and *Gobius bosc* Lacépède — all described in Lacépède's "Histoire naturelle des Poissons," vol. 2, pp. 104, 493, and 555, 1800) were taken in Charleston Harbor. Moreover, in Bosc's "Histoire naturelle des Vers," Volumes 1 and 2 (1801), the only references to his American collecting localities are: "Carolina" (two references), "the coasts of Carolina" (four references), "the marshes of Carolina" (one reference), and "Charleston Harbor" (ten references). Similarly, in his "Histoire naturelle des Coquilles" (ed. 2, 1824) Bosc mentions "the mouths of rivers in Carolina" (vol. 3, p. 37) and "the stagnant waters of Carolina" (vol. 3, p. 139), but otherwise, in Volumes 1-3, he seems to give no more definite records for this part of the world than "seas of America" or "coasts of America." One of his papers (Mém. Inst., vol. 8, pp. 307-373, 1807) deals with various oaks growing in France, but includes a number of North American species, for which no more definite localities are given than "Carolina."

Thus it would seem quite fitting to restrict the type locality of *Hyla ocularis* (and of virtually all of the other new species among Bosc's material) to the vicinity of Charleston, S. C. Among the other amphibian and reptilian species in this category are *Hyla femoralis* Bosc, *Hyla squirella* Bosc, *Stellio undulatus* Bosc and Daudin, *Testudo odorata* Latreille, *Testudo centrata* Latreille, *Testudo reticularia* Latreille, and *Testudo serrata* Daudin. The vicinity of Charleston is the type locality of *Hyla lateralis* Bosc and Daudin and of *Rana clamitans* Latreille by original designation.

Testudo odorata

The species so far considered in any detail in the discussion of Sonnini and Latreille's "Histoire naturelle des Reptiles" are amphibians that Daudin redescribed in his "Rainettes," claiming at the same time to have prepared the descriptions that had previously appeared in Latreille's part of the former work. Three turtles, a lizard, and a frog collected by Bosc, and a snake and a salamander collected by Palisot de Beauvois, now require comment.

The Eastern Musk Turtle (currently known as *Sternotherus odoratus*) is introduced in Sonnini and Latreille (vol. 1, p. 122) as *Testudo odorata*. Here Latreille says: "I owe the knowledge of this turtle to the naturalist Bosc, who has observed it in Carolina." After describing it, he adds (p. 124): "This

description . . . has been furnished me in major part by Citizen Bosc. . . . The Musk Turtle inhabits the stagnant waters of Carolina, where it is rare."

Daudin writes (Reptiles, vol. 2, p. 189, 1801): "It is to the naturalist Bosc that we owe the discovery of this species." He adds that the individual described by Bosc has been transmitted to himself. In a footnote on the same page he gives the following references: "*Tortue odorante*. Bosc, Description manuscrite communiquée. — *Idem*. Latreille, Hist. nat. des reptiles, in-18, tom. I, pag. 122." Bosc himself writes (Nouv. Dict. Hist. Nat., ed. 1, vol. 22, p. 267, 1804): "It is found in the marshes of Carolina, where I have observed, described, and drawn it."

On the evidence at hand, it seems necessary to conclude that Bosc supplied only the common name, and not the technical name. Therefore, although the description was mainly his own, the name *odorata* must evidently be credited to Latreille, with original reference as follows: *Testudo odorata* Latreille, in Sonnini and Latreille, Histoire naturelle des Reptiles, vol. 1, p. 122, pl. [5], fig. 3, 1801. As already pointed out, the type locality may be restricted to the vicinity of Charleston, S. C.

Testudo reticularia

This species, currently known as the Chicken Turtle *(Deirochelys reticularia)*, is introduced as *Testudo reticularia* in Sonnini and Latreille's Volume 1 (p. 124, 1801). Here we read (pp. 124-127): "This species, which Citizen Bosc had found in Carolina, and of which he has given me the description, accompanied by a drawing, is remarkable [etc.]. It is found, though rarely, in Carolina."

Later in the same year Daudin (Reptiles, vol. 2, p. 144, 1801) redescribes this turtle under the slightly modified name of *Testudo reticulata*, and remarks: "The naturalist Bosc has provided me with two turtles that he brought from North America. He has described one under the name of *tortue réticulaire*." In a footnote on the same page Daudin gives the following references: "*Tortue réticulaire, testudo reticularia*. Latreille, Hist. des reptiles, tom. I, pag. 124. — *Testudo reticulata*. Bosc, Description manuscrite communiquée." He also states (p. 147): "The *tortue réticulaire* lives in Carolina, where it is very rare, according to Bosc." Bosc himself contributes the final testimony (Nouv. Dict. Hist. Nat., ed. 1, vol. 22, p. 263, 1804): "It is found, but rarely, in Carolina, where I have observed, described, and drawn it."

It will be seen from the above that, by merely changing Bosc's manuscript name of *reticulata* into *reticularia*, Latreille became, whether by design or otherwise, the technical author of the species. Up to that point Bosc had done everything to qualify himself as the author: he had collected the type specimen, had prepared a drawing and a description (which Latreille used), and had provided the manuscript name of *Testudo reticulata*. If Latreille had not taken a slight liberty with the spelling of this specific name, Bosc would have had every right to stand as the sole author of the species. Under the International Rules, however, the original reference must apparently be cited as follows: *Testudo reticularia* Latreille, in Sonnini and Latreille, Histoire

naturelle des Reptiles, vol. 1, p. 124, pl. [6], fig. 1, 1801. The vicinity of Charleston, S. C., may be considered the type locality.

Testudo centrata

The original description of this Diamondback Terrapin, currently known as *Malaclemmys centrata centrata*, occurs in Sonnini and Latreille (vol. 1, p. 145, 1801). Here we read: "A man whom I [presumably Latreille] have mentioned several times, by reason of his researches and his works in all branches of natural history, Citizen Bosc, has transmitted to me the description and the drawing of this turtle, which he has brought from Carolina, a province which he has visited with an incredible ardor, in order to extend the domain of natural science."

Daudin (Reptiles, vol. 2, p. 153, 1801) says later of the same species: "The new species of turtle forming the subject of this description was discovered by the naturalist Bosc, who has kindly presented me with an individual, and who has turned over to me, with a generosity truly touching, all the reptiles of his collection."

In a footnote on the same page Daudin furnishes a Latin diagnosis of "*Testudo centrata*" and adds the following references: "Bosc, Description manuscrite communiquée. — Latreille, Histoire naturelle des reptiles, in-18, tom. I, pag. 145, pl. vi, fig. 2."

Bosc says (Nouv. Dict. Hist. Nat., ed. 1, vol. 22, p. 264, 1804) of this species: "It has been figured, after my drawing, by Latreille in the 'Histoire naturelle des Tortues,' Deterville edition, vol. 1, [pl. opposite] p. 124. It is found in the stagnant waters of Carolina, where I have seen it often in large numbers."

There is no evidence that Latreille had before him the specimen that Bosc presented to Daudin, or any other specimen. Apparently he relied entirely upon Bosc's description and drawing. In other cases, where technical names were proposed in manuscript by Bosc himself, Daudin gives references to these names, but it will be noted that he cites no Boscian name in the present case. Furthermore, in other cases where he himself claims to have prepared descriptions published by Latreille, he cites "Daudin, Hist. nat. des reptiles par Latreille"; but it is not so here.

Thus we may conclude that Latreille merely added the name *centrata* to the essential description supplied by Bosc, who, on purely ethical grounds, might be considered at least a joint author of the species. However, by a strict interpretation of Article 21 of the International Rules, presumably the original reference must be cited as follows: *Testudo centrata* Latreille, in Sonnini and Latreille, Histoire naturelle des Reptiles, vol. 1, p. 145, pl. [6], fig. 2, 1801.

Hay remarked as long ago as 1905 (Bull. U. S. Bureau Fisheries, vol. 24, p. 6) that "the type locality may be fixed with almost perfect certainty as Charleston, S. C.," but his quite appropriate statement seems to have been overlooked of late.

Stellio undulatus

The original description of the Pine Lizard (currently known as *Sceloporus undulatus*) occurs in Sonnini and Latreille (vol. 2, p. 40), and Latreille is generally credited with the authorship. But we read (p. 40) that "Citizen Daudin owes the knowledge and the description of this new species to the naturalist Bosc." This suggests the strong probability that *Stellio undulatus* belongs in the same category with the various new names of North American frogs that are introduced in the present work and for which Daudin (Rainettes, p. 12) claims credit as author. The latter says further (Reptiles, vol. 3, p. 384): "It is to him [Bosc] that I owe the knowledge of this species, of which Palisot Beauvois has subsequently furnished me with several individuals." Here Daudin also gives the following references for the species (which he now calls *Agama undulata*): "*Lacerta undulata.* Bosc, Description manuscrite communiquée. — *Le stellion ondulé.* Daudin, Hist. naturelle des reptiles, par Latreille, in-18, tom. II, pag 40." For his own part Bosc says (Nouv. Dict. Hist. Nat., ed. 1, vol. 21, p. 225, 1803): "It is found in Carolina, where I have observed, described, and drawn it."

It is thus evident that Bosc not only proposed the specific name but also furnished a manuscript containing a description of the new species. Daudin doubtless utilized this manuscript in preparing the description published in Sonnini and Latreille; possibly he modified it in some slight degree on the basis of his examination of the specimens received from Palisot de Beauvois, although the latter is not mentioned in the original description. Thus I consider Bosc and Daudin jointly as the real and responsible authors of the present species, and propose to cite the original reference as follows: *Stellio undulatus* Bosc and Daudin, in Sonnini and Latreille, Histoire naturelle des reptiles, vol. 2, p. 40, 1801.

The original description gives (p. 42) no more definite range than "les grand bois de la Caroline." As in the case of other Boscian species, I consider it appropriate to restrict the type locality to the vicinity of Charleston, S. C. In fact, since this was in manuscript, Smith (Occas. Papers Mus. Zool. Univ. Michigan, no. 387, p. 7, 1938) has taken such action.

Rana clamitans

The first description of the Green Frog, under the name given above, occurs in Sonnini and Latreille (vol. 2, p. 157). Here we read (p. 158): "This species has been found by the naturalist Bosc, in the fresh waters of Carolina, near Charleston."

It is next described in Daudin's "Rainettes" (p. 54, 1802), under the name of *Rana clamata.* Here no asterisk is attached to the name to indicate that it is one of the numerous species whose descriptions were prepared by Daudin for Sonnini and Latreille's work of 1801. Yet this very thing is suggested by the manner in which Daudin arranges the footnote references for the species in his "Reptiles" (vol. 8, p. 104, 1803), where he again uses the name *Rana clamata:* "*La grenouille criarde.* Daudin, Hist. nat. des rainettes, des grenouilles, etc. in-4°, p. 54, no. 5, pl. xvi, fig. 2. — *Idem.* Daudin, Hist.

nat. des reptiles par Latreille, in-18, tom. II, p. 157. — *Rana clamata*. Bosc, Note manuscrite communiquée."

Thus it appears that Bosc first proposed the name *Rana clamata* in manuscript, and that Daudin retained this name in two publications of his own, but that Latreille must have emended the specific name to *clamitans* in the first description to be published. While it is now impossible to determined just what part each of the three men may have had in drawing up that description, we must apparently grant to Latreille the technical credit of authorship, and the original reference may be cited as: *Rana clamitans* Latreille, in Sonnini and Latreille, Histoire naturelle des Reptiles, vol. 2, p. 157, 1801.

Coluber erytrogrammus

It is distinctly surprising that the original description of the Rainbow Snake (currently known as *Abastor erythrogrammus*) was apparently completely overlooked for more than a century; and although finally brought to light in recent years, it is still cited incorrectly. This must be largely on account of the rarity of the work in which it appeared. The original reference is: *Coluber erytrogrammus* Latreille, in Sonnini and Latreille, Histoire naturelle les Reptiles, vol. 4, p. 141, 1801. Here we read (pp. 141-142, translated): "Citizen Beauvois has discovered this new species in North America, and has made it known in a memoir read at the Institut National." No further information is given here concerning range or type locality. A search through the proceedings of the Institute (Institut de France, Acad. Sci., Procès-verbeaux Seances, vol. 1 (1795-1799), 1910, and vol. 2 (1800-1804), 1912) reveals notices of two papers on serpents by Beauvois during the years 1797-1798, but no mention of this particular species. The memoir in question is possibly the basis for the following reference by Duméril and Bibron (Erpétologie générale, vol. 7, p. 337, 1854): "1801. *Coluber erythrogrammus*. Palissot de Beauvois. Manuscrit."

It has been the common though erroneous practice to cite the original reference as follows: *Coluber erythrogrammus* Daudin, Histoire naturelle des Reptiles, vol. 7, p. 93, pl. 83, figs. 2a, 2b, 1803.[11] Although Daudin is in the habit of giving refernces to previously published species, for some reason or other he gives no such references here. He also makes no more definite statement as to range or type locality than "the United States of America, where it has been observed several times by Palisot Beauvois, who has kindly transmitted to me an individual from his collection."

There appears to be no definite clue in Beauvois' own works as to the provenance of his specimen, which was no doubt the type.

The first mention of a definite locality is apparently by Holbrook (N. Am. Herpetology, ed. 1, vol. 1, p. 117, 1836), who records specimens from the

11 After giving this as the original reference in the first three editions of their "Check List," Stejneger and Barbour have changed it in the fourth edition (p. 96, 1939) to the following: "*Coluber erythrogrammus* Latreille, Hist. Nat. Rept., Vol. 4, 1802, p. 141." Sherborn (Index Animalium 1801-1850, p. 2205, 1926) credits *Coluber erythrogrammus* to "P. A. Latreille, s. à Deterville ed. Buffon, Rept. IV, 1801, 141."

Santee and Cooper Rivers and Greenville, S. C. Holbrook also remarks (p. 117) that this species "was first noticed by Palisot de Beauvois, who found it in the southern States."

Among the places mentioned by Holbrook, the Cooper River would appear to be a suitable choice for a restricted type locality. Charleston is one of the southern cities visited by Beauvois (*cf.* his letter of May 20, 1796, to Dr. Casper Wistar in the library of the American Philosophical Society). Thus the type locality may be restricted a little further to the lower Cooper River, in the vicinity of Charleston, S. C.

The fact that the spelling *"erytrogrammus"* was preserved in the 1830 edition of Sonnini and Latreille (vol. 4, p. 141), while Latreille was still living, indicates that no strictly typographical error is involved, however faulty the etymology may be. Thus the name of the Rainbow Snake may be cited hereafter as *Abastor erytrogrammus* (Latreille).

One is tempted to suspect that possibly this is another one of the species whose descriptions were prepared by Daudin for Sonnini and Latreille's work, and that later realization of the etymological imperfection deterred this sensitive young man from referring in his work of 1803 (where the spelling is *"erythrogrammus"*) to the first publication of the name.

Salamandra rubra

The original description of the Red Salamander occurs in Sonnini and Latreille's Volume 4 (p. 305). Among those who cite the name from this place, Daudin (Reptiles, vol. 8, p. 227, 1803), Holbrook (N. Am. Herpetology, ed. 1, vol. 4, p. 123, 1840), and Duméril and Bibron (Erpétologie générale, vol. 9, p. 89, 1854) credit it to Latreille; on the other hand, Stejneger and Barbour (Check List N. Am. Amphibians Reptiles, p. 20, 1917; p. 15, 1923; p. 17, 1933; p. 22, 1939) and Dunn (Salamander Family Plethodontidae, p. 272, 1926) credit it to Sonnini.

The "avertissement" of Volume 1 (p. ii) states that the account of the salamanders [vol. 2, pp. 188-264] is of Sonnini's authorship. This may be assumed to be perfectly correct. But the description of *Salamander rubra* occurs in the "Éclaircissemens et Additions" to Volume 4 (pp. 239-315), which were evidently prepared after Volumes 1 and 2 had gone to press. Therefore it is not at all necessary to consider that the statement in Volume 1 applies to the "Éclaircissemens et Additions." In these accounts, which comprise only four salamanders among numerous other amphibians and reptiles, there is much use of the first person singular, and there is no break or change to set off the accounts of the salamanders from those of species in other groups.

In the account of "la salamandre terrestre" (vol. 4, p. 303) we read (translated): "I have combated the opinion of those who believed that this species was oviparous, and that it deposited its eggs in the water, in the same manner as the aquatic salamanders." This is pretty clearly a reference to Latreille's own "Salamandres de France" (pp. 13, 19-20, 1800).

Daudin himself had a hand in the production of the present work, and was in an exceptionally good position to be informed as to the respective parts

prepared by Latreille and by Sonnini. Furthermore, Sonnini was editor of Daudin's "Reptiles," the first subsequent work in which the name was credited to Latreille. Under these circumstances the likelihood of a mistake in the reference by Daudin and other early authors becomes reduced to a minimum. The original reference of the species (which is currently known as *Pseudotriton ruber*) should almost certainly be cited as follows: *Salamandra rubra* Latreille, in Sonnini and Latreille, Histoire naturelle des Reptiles, vol. 4, p. 305, 1801.

In the original description no more definite information was given regarding its range than the fact that it was found "dans les Etas-Unis." Dunn is very likely justified in suggesting (Salamander Family Plethodontidae, p. 274, 1926) that the type locality is "probably near Philadelphia." It may be recalled that Palisot de Beauvois, who collected the type specimen of *Salamandra rubra*, described in 1799 (Trans. Am. Philos. Soc., vol. 4, p. 279) a larval salamander from the present site of Camden, N. J., under the name of *Siren operculata*. This has been generally regarded as probably synonymous with *Salamandra rubra*, and it has two years' priority over the latter name.

Duméril and Bibron (Erpétologie générale, vol. 9, p. 89, 1854) give as a reference "1796. *Salamandre rouge*. Palisot Beauvois," but I have been quite unable to locate this in the literature. It is perhaps a mere manuscript name on a specimen label.

Daudin's "Histoire naturelle des Reptiles"

In the original edition of this work, Volumes 1-4 are dated "An X," and Volumes 5-8 "An XI." In a second set at the Academy of Natural Sciences of Philadelphia, Volumes 1 and 2 are reprints, bearing the date "An XIII." In the first of these sets the plates are colored; in the second set they are uncolored. Each volume of the work is of octavo size.

The first two volumes were presented by Daudin to the French Academy of Sciences at its seance of 26 Frimaire, An X [December 17, 1801], and two other volumes, whose numbers are not specified but which may be rather safely assumed to be Volumes 3 and 4, were presented at the seance of 23 Thermidor, An X [August 11, 1802] (Institut de France, Acad. Sci., Procès-verbeaux Seances, vol. 2 (An VIII-XI), pp. 443, 548, 1912). Thus the date of publication of Volumes 1 and 2 may be set at December, 1801, and of Volumes 3 and 4, at August, 1802.[12]

Volume 5 contains references (pp. 276, 336) to No. 72 of the "Bulletin de la société philomathique," which was the issue for Ventose, An XI [February 20-March 21, 1803]; also a reference (p. 336) to the "Magasin encyclopédique," vol. 5, p. 433, 1803, which was apparently issued about March or April. This fixes the date of publication of Volume 5 approximately between April and September, 1803. Evidently the dates for Volumes 6 and 7 fall

12 In the four editions (1917-1939) of Stejneger and Barbour's "Check List," Daudin's Volumes 2 and 4 have been consistently cited as of 1803. Sherborn (Index Animalium 1801-1850) cites the new species in Volume 2 as of 1802.

within the same limits. In Volume 7 (pp. 352, 355) there is reference to the recent publication of the "Nouveau Dictionnaire d'Histoire naturelle," vol. 1, which appeared in An XI (1803). Volume 8 contains (p. 439) a note dated "11 juillet, 1803"; thus the date of its publication is probably August or September, 1803.[13]

Baron Cuvier, apparently always critical of Daudin and his work, is nevertheless constrained to acknowledge (in Michaud, Biographie universelle, nouv. ed., vol. 10, p. 161, 1855?) the importance of the "Reptiles." This tribute is doubtless all the more significant in that it comes from a grudging critic. A condensed and rather free translation follows:

"Although still far from what it might have been, this work is beyond contradiction the most complete that we have on this curious class of animals. Since Lacépède's work of 1789 the number of known species had more than tripled. It had become necessary to establish a more detailed classification, and this Daudin did with much care. He based his genera on rather good characters, and described — or at least was the first to arrange in their order — many new or neglected species. He might have had a more profound knowledge of anatomy and more skill in appraising the diverse testimony of travelers and naturalists. He had no pretentions to elegance of style, nor to general views of philosophy. Despite imperfections, this is now the principal work, and the one to which those must refer who make new researches in this branch of natural history."

As far as North America is concerned, this work is important, in the first place, in that it utilizes the accounts of several species that had been published in Bartram's "Travels" (1791). Daudin was apparently the first professional herpetologist to make use of this opportunity. He had before him one or the other of the two French editions of Bartram, issued in 1799 and 1801. As we have already seen, Daudin copies (Reptiles, vol. 2, pp. 256-259) from this source the description and name of Bartram's *Testudo polyphemus;* furthermore, he bases his *Rana grunniens* (in Sonnini and Latreille, vol. 2, p. 155, 1801), his *Testudo bartrami* (Reptiles, vol. 2, p. 74), and his *Coluber melanoleucus* (Reptiles, vol. 6, p. 409) on Bartram's accounts. Bartram is also cited in various other places.

Secondly, Daudin avails himself once more of Bosc's material and notes in describing *Testudo serrata* (vol. 2, p. 148). He also redescribes herein the various Boscian species whose original descriptions had appeared either in his own "Quadrupèdes ovipares" (1800) or in Sonnini and Latreille's "Reptiles" (1801).

In the third place, he introduces the new genus *Anolis* (vol. 4, p. 50) and the new species *Crocodilus mississipiensis* (vol. 2, p. 412) and *Salamandra alleganiensis* (vol. 8, p. 231). The types of these two species had been collected in the United States by Daudin's compatriot André Michaux.

13 As far as available records go, Daudin did not present Volumes 5-8 to the French Academy of Sciences. His failure to do so may have been one of the consequences of his differences with Lacépède in October, 1802, over his use of the latter's specimens (*cf.* Reptiles, vol. 5, pp. 5-6).

Testudo Bartrami

This name, introduced by Daudin (vol. 2, p. 74), is based on "the great soft shelled tortoise" or "tortue à écailles douces" of Bartram (Voyage, vol. 1, p. 307, 1799 or 1801). Daudin also cites *"Testudo (ferox?) verrucosa Bartrami.* Schoepff, Hist. testud. pag. 90," 1792. Schoepff, however, wrote "TESTUDO (FEROX?) VERRUCOSA. *Bartrami,"* and the context shows clearly that *"Bartrami"* is used as a reference, not as a name for the Soft-shelled Turtle. Consequently Daudin stands as the author of *Testudo Bartrami.*

The identity of this animal has been discussed by Holbrook (N. Am. Herpetology, ed. 1, vol. 4, pp. 10, 15-16, 1840; ed. 2, vol. 2, pp. 12, 17-18, 1842) and by Le Conte, (Annals Lyceum Nat. Hist. New-York, vol. 3, pp. 96-97, 1830; Proc. Acad. Nat. Sci. Philadelphia, vol. 7, pp. 12-13, 1854). Bartram's drawings (Travels, pls. following p. 176, 1791) show tubercles on the sides of the head and neck and five claws on each of the hind feet. These characters, if actual, would distinguish his species from the Southern Soft-shelled Turtle, which is currently known as *Amyda ferox* (Schneider); but they may be regarded as representing either individual variations in one specimen or as inaccuracies on Bartram's part. Thus *Testudo bartrami* Daudin may be considered a synonym of *Testudo ferox* Schneider (Naturg. Schildkröten, p. 330, 1783).

Bartram (Travels, pp. 177-178, 1791) includes his description in a narrative of his camping at "Halfway Pond," in the region between the present Palatka and Gainesville, Fla.: "Here are, as well as in all the rivers, lakes and ponds of East Florida, the great soft shelled tortoise." Thus the "Halfway Pond" may be considered the restricted type locality of *T. bartrami* Daudin. The location is evidently somewhere in southwestern Putnam County, although Bartram's name for the pond has fallen into disuse.

Testudo serrata

This name (vol. 2, p. 148) is based upon a specimen brought from "Carolina" by Bosc. He also furnishes some descriptive notes on the fleshy parts, which Daudin adds to his own description of the shell. The name, however, is evidently proposed by Daudin and must be credited to him alone. The vicinity of Charleston may be regarded as the restricted type locality.

This species has been generally considered identical with the Yellow-bellied Terrapin, *Pseudemys scripta* (*Testudo scripta* Schoepff, Historia Testudinum, p. 16, pl. 3, figs. 4-5, 1792), which has nine years' priority.

Bosc writes (Nouv. Dict. Hist. Nat., ed. 1, vol. 22, p. 264, 1804) of *T. serrata:* "It is figured in Daudin, vol. 2, pl. 21, from an individual that I brought back from Carolina, where it is found in the marshes. . . . Daudin, by error, has attributed to this species the description that I had made of the preceding one [*T. reticularia*] from a living specimen."

This remark of Bosc's indicates that the *serrata* of Daudin is a composite species. In that case the description furnished by Bosc (*op. cit.*, p. 264) should determine the application of the name. It actually applies quite distinctly to *serrata (i. e., scripta),* not to *reticularia.*

Crocodilus mississipiensis

This original name of the American Alligator (currently known as *Alligator mississipiensis*) is introduced in Daudin's Volume 2 (p. 412). The author states (pp. 412-413) that the elder Michaux (1746-1802) "has given to the Paris Museum of Natural History a crocodile that he killed on the borders of the Mississippi." Michaux, however, makes no mention of the Alligator in that part of his travels, although he refers to it in the Savannah River valley below Augusta, Ga. (Proc. Am. Philos. Soc., vol. 26, no. 129, p. 14, 1889). He does not seem to have visited the Mississippi much below the mouth of the Ohio, and, as far as we know, the Alligator did not ascend the river to that latitude even in Michaux's day. Under these circumstances, he was perhaps more likely to have secured a trade skin from farther down the river than to have killed a specimen himself. Thus there is practically no clue as to the exact provenance of Michaux's specimen. In any event, it is difficult to comprehend why he should have taken the trouble to transport a specimen on a long and arduous journey overland from the Mississippi when the animal was plentifully available about his home near Charleston, S. C.

Daudin himself (vol. 2, p. 415) quotes Lacoudrenière to the effect that the species "is found only in the warmest part of lower Louisiana, for it is not met with above the Red River." While Lacoudrenière erred in so restricting the range of the Alligator, his statement, as utilized by Daudin, may serve as a convenient basis for restricting the type locality to that part of the Mississippi River lying between the mouth of the Red River (at about latitude 31° N.) and its own mouth.

Coluber melanoleucus

In a hitherto unpublished account of the snakes of East Florida, Bartram writes (Report to Dr. Fothergill, MS, vol. 2, p. 53, 1775?): "The Thunderer or The Bull Snak, commonly called the horn Snake from his tail terminating by a hard sharp point like a young cock spur, they are very harmless but of a monstrous size and bulk, they are frequantly above seven feet in length & 6 inches in diameter of a pied colour black & white. when provoked they swell themselves & utter a loud thundering noise, but can t be provoked to strike, but indeavour to escape in holes in dry sand hills."

This is an entirely unmistakable account of the Pine Snake, more recently known as *Pituophis melanoleucus* (Daudin). It is especially important in showing that Bartram fixed its range in "East Florida," despite an apparent error in the statement of color. For the form of Florida and southern Georgia[14] is brown and white, while black and white individuals are found from South Carolina northward.

In a published account of "snakes in the regions of Florida and Carolina," Bartram (Travels, p. 276, 1791) describes this species again: "The pine or bull snake is very large and inoffensive with respect to mankind, but devours squirrels, birds, rabbits, and every other creature it can take as food. They

14 I have seen a brown and white individual in Charlton County, Ga., and H. L. Stoddard tells me that the form about Thomasville, Ga., is similar.

are the largest snake yet known in North America, except the rattle snake, and perhaps exceed him in length: they are pied black and white: they utter a terrible loud hissing noise, sounding very hollow and like distant thunder, when irritated, or at the time of incubation, when the males contend with each other for the desired female. These serpents are also called horn snakes, from their tail terminating with a hard, horny spur, which they vibrate very quick when disturbed, but they never attempt to strike with it; they have dens in the earth, whither they retreat precipitately when apprehensive of danger."

Coluber melanoleucus Daudin (Reptiles, vol. 6, p. 409, 1803) is based on "le serpent pin ou taureau" of the French edition of Bartram (Voyage, vol. 2, p. 18, 1799 or 1801). Daudin remarks that this species was discovered by Bartram in Florida. After quoting Bartram's description, he adds: "Palisot Beauvois never found this snake in Pennsylvania or the other parts of the United States that he traversed; nevertheless it appears that it is known to the inhabitants of South Carolina and Florida."

Thus the evidence from Daudin as well as from Bartram tends very strongly to fix the type locality of *C. melanoleucus* in Florida, though we must admit that the color description does not apply to the form of that state.

On the other hand, Barbour, without being aware of Bartram's manuscript account, proposes to restrict the type locality of *melanoleucus* to "Carolina," and to apply that name to the black and white form, while introducing the name *Pituophis melanoleucus mugitus* (Proc. New England Zoöl. Club. vol. 7, p. 117, 1921) for the brown and white form, with type locality "ten miles north of West Palm Beach, Florida."

But the distribution of the two forms in South Carolina appears to be just the opposite of one's natural expectations. Rea (Bull. Charleston Mus., vol. 6, p. 47, 1910) has recorded a black and white specimen from Archdale on the Ashley River, about a dozen miles from Charleston (therefore in the Coastal Plain), and two brown and white specimens from Walhalla, in extreme northwestern South Carolina (Piedmont region). I have recently examined in the Charleston Museum still another specimen of the latter type, from Leesville, Lexington County, which seems to be a sort of common ground for both Piedmont and Coastal Plain species.

It seems quite possible that Bartram had noted the black and white form in South Carolina, and had thus been led into erroneously ascribing that coloration to the Florida form, which he was primarily describing. It might thus be permissible to retain the name *Pituophis melanoleucus* for the brown and white Florida form, and in that case it would probably be necessary to reduce *mugitus* to synonymy. But before attempting to apply some new name to the black and white form ranging from New Jersey to South Carolina, a further inquiry into the distribution and relationships of all forms of *Pituophis* in the Eastern States would be in order.

As a final bit of evidence on the type locality of *melanoleucus*, it may be remarked that the "holes in dry sand hills" or "dens in the earth," which Bartram mentions as a refuge for the Pine Snake, are doubtless the burrows

of the Gopher Turtle *(Gopherus polyphaemus)*. I have seen one of these snakes use such a refuge in Charlton County, Ga. As shown on a previous page, Bartram records the Gopher Turtle and its burrows only in Georgia and Florida.

Salamandra alleganiensis

The Hellbender (now known as *Cryptobranchus alleganiensis*) was first described by Sonnini (in Sonnini and Latreille, Reptiles, vol. 2, p. 253, pl. 54, fig. 1, 1801) as "la salamandre des monts Alléganis," but no technical name was then bestowed. It was also described under the same common name by Bosc (Nouv. Dict. Hist. Nat., ed. 1, vol. 20, p. 48, 1803).

The first technical name, *Salamandra alleganiensis*, was proposed by Daudin (Reptiles, vol. 8, p. 231, 1803). He states that the animal was obtained by André Michaux "dans les monts Alléganis, en Virginie." However, a careful perusal of the elder Michaux's journal (Proc. Am. Philos. Soc., vol. 26, no. 129, pp. 1-145, 1889; also in Thwaites' "Early Western Travels 1748-1846," vol. 3, pp. 25-104, 1904) reveals no mention of the species.

Fortunately the son, François André Michaux, in the course of some general observations on the Allegany Mountains (Travels to the westward of the Allegany Mountains, pp. 316-317, 1805, London), has furnished an essential clue to the type locality:

"A species of salamander is found in the torrents, called by the inhabitants the *Alligator of the Mountains;* some of them are two feet long. The specimen described in the Nouveau Dictionnaire d'Histoire Naturelle, published by Deterville, was taken in Doe River by my father."

On first consideration, this would appear to be the Doe River that lies in Carter County, Tennessee, and discharges into the Watauga at the present site of Elizabethton. On closer investigation, however, it becomes evident that the younger Michaux confused the names Doe and Toe and actually meant the latter river in the present case.

The elder Michaux had stopped more than once (August 16-19 and September 1-5, 1794; May 4-13, 1795; March 23-29, 1796) at Davenport's plantation on the North Toe River. According to Price and Strother's map of North Carolina (1808), this was situated on the west side of the river in Mitchell County, N. C., approximately a mile south of the mouth of the present Brushy Creek (Morganton quadrangle) and 4 miles ENE. of the present Spruce Pine (Mount Mitchell quadrangle). Michaux had also made considerable excursions and botanical collections in this vicinity.

The son, in the course of his own travels some years later, likewise stopped here. He says (*op. cit.*, p. 309): "I . . . arrived at the house of one Davenport, the owner of a charming plantation upon Doe River, a torrent about forty feet in breadth, and which empties itself into the Nolachuky." (It is the Toe River, not the Doe River, that empties into the Nolichucky.)

Since the younger Michaux was apparently consistent in misnaming the Toe River, and since the father spent considerable time on this river, we are no doubt justified in interpreting the former's statement of the type locality

as applying to the (North) Toe River. The most likely part of this river for the collection of the type specimen was probably the vicinity of Davenport's plantation. This, then, may be considered the restricted type locality.

Stejneger and Barbour (Check List, ed. 4, p. 4, 1939) follow Daudin quite literally in stating that the type locality is the "Allegheny Mountains in Virginia." But either Daudin's information was faulty, or his concept of the boundaries of Virginia was rather vague.

Daudin's "Histoire naturelle des Rainettes, des Grenouilles et des Crapauds"

This work is well planned and executed, and it is adorned with large and nicely colored plates. The Latin diagnoses and the lists of references or synonyms indicate a professional touch. It is virtually a monograph of the genera *Hyla, Rana,* and *Bufo* as known in 1802. All in all, it is certainly one of the most sumptuous herpetological works of its period. Although its more ambitious forerunner, the "Quadrupèdes ovipares," had had to be abandoned when barely under way, through pressure of financial difficulties, nevertheless Daudin, by restricting the scope of the present work (and incidentally changing publishers), was able to carry it to completion in both a quarto and a folio edition.

There is no consensus of opinion as to the date of publication. The various authorities seem unable to agree as to whether it was 1802 or 1803. I have not yet unearthed any final evidence. However, the work is reviewed in Millin's "Magasin encyclopédique" (8th year, vol. 5, pp. 272-273 — apparently issued about March, 1803), and therefore the "Rainettes" could not have been published later than the very early part of that year. Hoefer (Nouvelle Biographie générale, vol. 3, p. 175, 1855) cites 1802 for both the quarto and the folio editions. Sherborn (Index Animalium 1801-1850, p. xlii, 1922) gives this date. I am provisionally considering 1802 as the date of publication.

A single set of engravings was evidently employed for printing the plates of the two editions, those of the folio edition merely being printed on larger sheets of paper. There is no change in the numbering of the plates. There is a change of spelling on Plate 10, from "*hypochondrialis*" in the quarto edition to "*hypocondrialis*" in the folio edition.

In making citations from the "Rainettes," it is advisable to specify the edition used, since the pagination is almost entirely different in the two editions. For example, *Rana clamata* is introduced on page 54 of the quarto edition, and on page 35 of the folio edition; *Rana grunniens,* on page 65 of the quarto edition, and on page 42 of the folio edition.

Aside from the pagination, the text is presumably identical, or very nearly so, in the two editions, although I have been unable to bring copies of both together for collating.

In the review mentioned above, Millin lists as new seven species each of *Hyla, Rana,* and *Bufo.* All of these, however, had been previously published either in Daudin's "Quadrupèdes ovipares" or in Sonnini and Latreille's

"Histoire naturelle des Reptiles," or in both works. Curiously enough, Millin overlooks a dozen actually new species and new names. These are given in the following list, together with the pages on which they are introduced in the quarto edition, and the ranges as originally stated:

Hyla variegata, p. 20: Surinam. (A renaming of *Hyla intermixta* Daudin, 1801.)

Hyla blochii, p. 43: East Indies. (A renaming of *Calamita cinerea indica* Schneider, 1799.)

Hyla surinamensis, p. 44: Surinam.

Rana punctata, p. 51: France.

Rana plicata, p. 53: France.

Rana clamata, p. 54: South Carolina. (A renaming of *Rana clamitans* Latreille, 1801.)

Rana tigerina, p. 64: Bengal.

Bufo chlorogaster, p. 74: Java. (Labeled "*Bufo flaviventris*" on pl. 25.)

Bufo laevis, p. 85: locality unknown.

Bufo surinamensis, p. 91: Surinam.

Bufo bengalensis, p. 96: Bengal.

Bufo horridus, p. 97: locality unknown.

In addition to the new species, a feature of great interest and significance is Daudin's statement on page 12, in which he makes the almost certainly valid claim that he prepared the descriptions of a considerable number of species in Sonnini and Latreille's work of 1801. This statement has already been quoted and discussed in the review of the latter work.

Millin (*op. cit.*, p. 273) justly remarks on the importance of the present work, on the accurate descriptions, and on the carefully done figures.

Bosc (in Nouv. Dict. Hist, Nat., ed. 1, vol. 19, p. 182, 1803) pays the following warm tribute to the "Rainettes": "Latreille, in the work cited above [Histoire naturelle des Reptiles], records 18 species of *Hyla*, the majority discovered in the collections of Paris by Daudin, who has already published some fascicles of a monograph[15] of this genus, which was noteworthy in

15 This statement of Bosc's, standing alone, might be interpreted as applying to the "Quadrupèdes ovipares" rather than to the "Rainettes," since the two separately published livraisons of the former include only the genus *Hyla*. However, certain remarks made by him in previous volumes of this dictionary show rather unmistakably that he refers to the "Rainettes." For example, he calls attention (vol 10, p. 133, 1803) to the "superb monograph" just published by Daudin, in which the latter makes known more than twice as many species of *Rana* as Latreille had in 1801. Again (vol. 6, p. 486, 1803), he refers to Daudin's monograph as containing 24 species of *Bufo*. It will be recalled that these last two genera were not included in the two published livraisons of the "Quadrupèdes ovipares."

Thus Bosc's remark on the publication of "some fascicles" of the monograph might be taken to indicate that the "Rainettes' appeared in parts, although I have discovered no other evidence to this effect. In such a case, at least the early fascicles must have appeared in 1802, and the last ones not later than January or February, 1803.

natural history by reason of the clarity of its descriptions, the soundness of its critique, and the beauty and accuracy of its figures. One can only recommend its acquisition to the naturalists who would like more extensive details on the tree-frogs, animals as elegant in their form as they are agreeable in their colors."

Baron Cuvier, who, despite his great name, was probably a less competent judge of the present work than Bosc, can scarcely be considered to have done justice to so important a monograph in his brief and critical appraisal (in Michaud, Biographie universelle, nouv. ed., vol. 10, p. 162, 1855?): "It is only a collection of colored plates with accompanying descriptions. The colors are not always to be trusted, having been taken only from specimens altered by the preserving fluid.[16]

Such lack of appreciation reflects more, perhaps, upon the critic than upon the author of the work reviewed. Cuvier says practically nothing of the text, which, with its excellent and progressive features, is of far greater consequence than the exact manner in which the plates happen to be colored. In the matter of nomenclature, at least, this work of Daudin's contrasts most favorably with Lacépède's "Histoire naturelle des Poissons," vol. 1 (1798), which, after a generation of Linnaean nomenclature, still had not reached the point of uniformly providing the species with binominal names! Cuvier's own brief treatment of amphibians and reptiles in his "Regne animal" (vol. 2, 1817) can not compare, either in nomenclatural details or in the general accounts, with Daudin's productions. Moreover, the renowned Latreille, "Prince of Entomology," fell considerably short of Daudin's standards in his work with Sonnini on the "Histoire naturelle des Reptiles."

SWARTHMORE, PA.

16 Daudin himself makes this remark (p. 12) concerning the coloring of *some* of his species.

Two New Amoebae from the Box Elder Bug, Leptocoris trivittatus Say*

Maire Weir Kay

While examining specimens of the box elder bug collected (1936-1938) in Salt Lake City for flagellates several other protozoa were observed from time to time. Of these, two, both Endamoebidae, were found with sufficient frequency and in large enough number to make their identification possible. The descriptions which follow are based on the examination of specimens in smears fixed with Schaudinn's fluid or osmic acid vapor, stained with Heidenhain's haematoxylin and mounted in balsam.

Since no amoebae have previously been reported from this host and because of certain nuclear characteristics it appear that the organisms under observation are new to science. One species can be definitely designated as belonging to the genus *Endolimax* Kuenen and Swellengrabel while the other is distinctly a member of the genus *Entamoeba* Casagrandi and Barbagallo.

Endolimax leptocoridis sp. nov.

This amoeba is found in the alimentary canal of the host, both the adult and the nymph. The trophozoites and the cysts are limited to the intestine and rectum, but certain developmental stages are found in the ventriculus.

Morphology of the Trophozoite
(Figs. 1, 4)

The adult amoeba is of moderate size, varying in length from 10-40 μ and in breadth from 6-30 μ. The nucleus is small, its diameter in the largest specimen not exceeding 6 μ. It is surrounded by a thick, lightly staining membrane which is occasionally connected with the endosome by fibrils. This endosome is large, frequently nearly filling the nucleus, and consists of a central achromatic mass in which are embedded a variable number of large chromatin granules. There is little if any diffuse chromatin in the peripheral area of the nucleus. The cytoplasm is rather sharply demarked into endoplasm and ectoplasm, and the few pseudopodia are commonly narrow and angular. Very many inclusions are regularly present in the endoplasm which appear to be food vacuoles containing bacteria, flagellates and other materials from the intestinal content.

The Precystic Form
(Fig. 3)

In size the precystic trophozoite is similar to the active form. It is notably different in the absence of pseudopodia and of food inclusions. In most of

* I wish to take this opportunity to express my deep gratitude to Dr. John E. Guberlet whose assistance in identifying this material and in preparing this manuscript has been invaluable.

the specimens observed the nucleus had divided and was undergoing further divisions. During fission the chromatin is apparently distributed throughout the achromatic matrix as in all the cases observed the endosome was elongated into a dumb-bell like form in which no separate chromatim granules were visible. Some of the precystic amoebae contained densely staining, irregular chromatoidal bodies.

The Cyst
(Fig. 9)

The range in size of the oval cyst is similar to that of the trophozoite. To the inner surface of the relatively thin, smooth cyst wall the cytoplasm is closely adherent. Within lie a variable number of nuclei, rarely less than 32 and in no observed case more than 64. Except in size these nuclei have all the characters of the trophozoite nucleus.

Excystment and the Formation of Amoebulae
(Fig. 5)

When the cyst is ingested by a new host it commences its vital activities in the ventriculus of that host. Here the cyst wall becomes thinner, probably through the action of the digestive fluids of the host, until a portion of it entirely disappears. With this occurrence marked changes take place in the cyst contents: the whole body enlarges and becomes much less sharply staining; numerous vacuoles appear in the cytoplasm, particularly in the region where the cyst wall is wholly gone; and profound changes occur in the nuclei adjacent to the break in the wall.

The nuclei tend to migrate towards the opening in the cyst wall. During this migration their structure is considerably modified. First the chromatin masses become a more or less continuous thread twisted about the achromatic portion of the endosome; the nucleus enlarges; the endosome become branched and irregular; densely staining granules appear in the cytoplasm, and the endosome breaks into fragments. At this stage the achromatic portion of the endosome is completely obscured. Immediately thereafter the nuclei are budded off, each one being surrounded by a very thin rim of cytoplasm.

It has been impossible to determine the details of the fate of the amoebulae in the preparations available. However, the complex steps leading to their release suggests a process of gamete formation. It is at least possible that they may undergo a sexual fusion equivalent to that described by Mercier (1910) for *Endamoeba blattae*.

The next form to be recognized is a small amoeba (Fig. 6) found in both the ventriculus and the intestine, which has essentially the characters of the adult but is much smaller, usually about 5 μ in length. At this stage the large endosome has reappeared, but the chromatin granules on its surface are not evident, and the endosome is connected with the nuclear membrane by granular threads. The relative amount of cytoplasm is considerably greater than that of the amoebula, and a few food inclusions may be present. Various intergradations between this stage and the typical adult trophozoite are found, particularly in the upper portion of the intestine.

The nuclear characters of the amoeba under consideration agree so completely with those cited by Wenyon (1926) and Kudo (1931) for the genus *Endolimax* that there is no doubt that it should be assigned to this genus. On the other hand several characters appear to differentiate it from all other species included in this genus. Its maximum size, equalled only by *Endolimax reynoldsi* from the common swift (McFall 1926), and the regular occurrence of a cyst with more than eight nuclei, a condition not reported for any other species, make it distinctive. In addition it is the first amoeba to be reported from this host. For these reasons it appears advisable to consider this form as a new species and to describe it under the name *Endolimax leptocoridis*.

Host: Nymph and adult of *Leptocoris trivittatus* Say.

Habitat: Ventriculus, intestine and rectum.

Locality: Salt Lake City, Utah.

Entamoeba polypodia sp. nov.

This amoeba has been found to be present in the ventriculus, intestine and rectum of about 10 percent of the box elder bug nymphs examined. The amoebae were not present in great numbers in any case.

Morphology of the Trophozoite
(Figs. 2, 7)

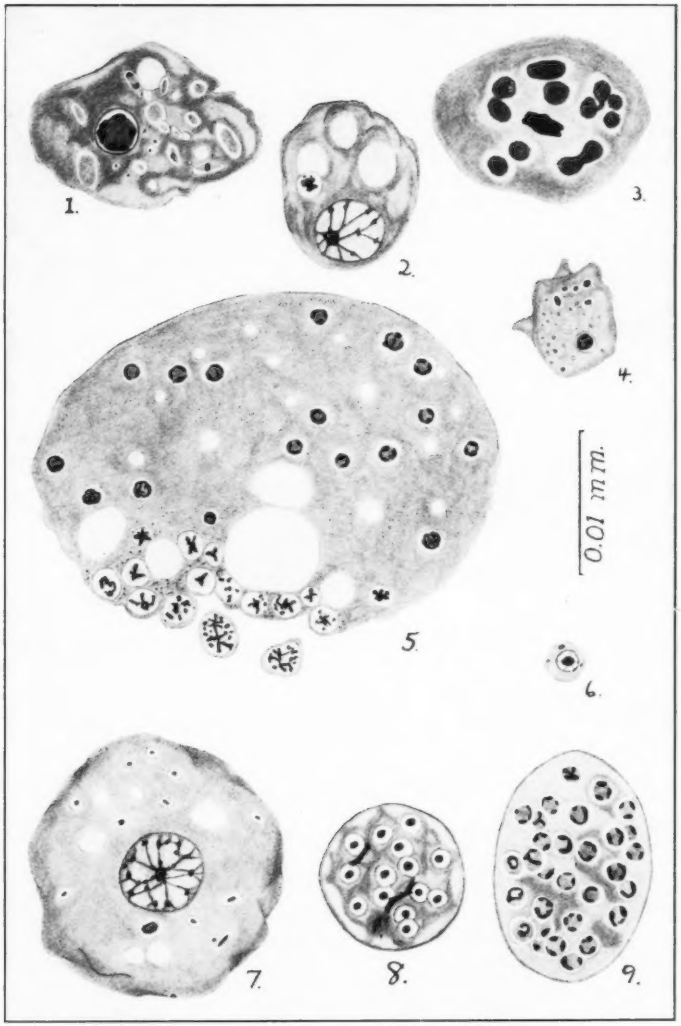
The adult amoeba is somewhat larger than the preceding species, averaging 15-45 μ in length and the same in breadth. The nucleus is large with an irregular, often excentric endosome. There are regularly a number of large chromatin granules distributed about the outer portion of the nucleus; these are connected to the nuclear membrane and to the endosome by achromatic threads. Very little chromatin is found encrusted on the nuclear membrane. The cytoplasm exhibits a thin layer of clear ectoplasm surrounding an endoplasmic mass which is usually somewhat vacuolated and which may contain food vacuoles. There are usually present a number of short, broad, blunt pseudopodia.

Morphology of the Cyst
(Fig. 8)

Precystic forms of this amoeba have not been identified. From the appearance of the cyst it may be determined, however, that the following steps take place in its formation. The size of the protoplast is reduced; food inclusions and vacuoles are discharged; chromatoidal bodies are formed, and several nuclear divisions take place.

The cyst is a spherical body from 10-25 μ in diameter, with a relatively thick wall from which the cytoplasm is somewhat withdrawn. It contains 8-16 nuclei with thick walls and central, densely staining endosomes. One or more dark, irregular chromatoidal bodies are also present.

This amoeba shows so many points of general resemblance to members of the genus *Entamoeba* that no doubt can be felt as to the propriety of including it therein. In comparison with the forms recorded from other insect hosts it does, however, show certain individual characters which appear to justify its



Endolimax leptocoridis sp. nov. Figs. 1 and 4. Mature trophozoites showing typical nuclei and pseudopodia. Fig. 3. Precystic trophozoite with dividing nuclei and with parabasal body. Fig. 9. Cyst with 28 nuclei visible and no distinct chromatoidal body. Fig. 5. Excysting plasmodium with typical nuclear changes and amoebula formation. Fig. 6. Small trophozoite from the ventriculus.

Entamoeba polypodia sp. nov. Figs. 2 and 7. Trophozoites with characteristic nuclei and blunt pseudopodia. Fig. 8. Cyst with 14 nuclei and characteristic irregular chromatoidal bodies.

description as a new species. Its size is somewhat greater than that of any of these species for which definite measurements have been given. The occurrence of most of the peripheral chromatin distinctly separated from the nuclear membrane while recognized within the genus (Wenyon 1926) is not reported for any *Entamoeba* from an insect. The number of nuclei in the cyst, 8-16, differs from previous reports; up to 10 in *E. minchini* MacKinnon (1914), 2-4 in *E. mesnili* Keilin (1917), not recorded in *E. apis* Fantham and Porter (1911) and in *E. belostomae* Brug (1922) the cyst is unrecorded. For these reasons it seems advisable to consider this amoeba as distinct from previously reported species and to designate for it the name *Entamoeba polypodia.*

Host: Nymph of *Leptocoris trivittatus* Say.

Habitat: Ventriculus, intestine and rectum.

Locality: Salt Lake City, Utah.

Summary

Two species of amoeb , *Endolimax leptocoridis* and *Entamoeba polypodia* from the alimentary canal of the box elder bug, *Leptocoris trivittatus* Say, are described. In the case of the former some observations are made on peculiar nuclear changes which take place during excystment and are suggestive of steps preceding a sexual process.

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A New Trematode, Neorenifer serpentis, from the Water Moccasin*

Fred L. Schmidt and W. Eugene Hubbard

In the oesophagus of a water moccasin, *Agkistrodon piscivorus* (Lacépède 1789), taken in June, 1939, near Lewisville, Arkansas, 30 specimens of an apparently new reniferinan reniferid fluke were found. The worms were fixed in acetic-sublimate solution, stained in borax carmine, and mounted *in toto*. The description that follows is based on the study of 5 of the largest specimens, the others being subadult. The measurements are all from preserved material.

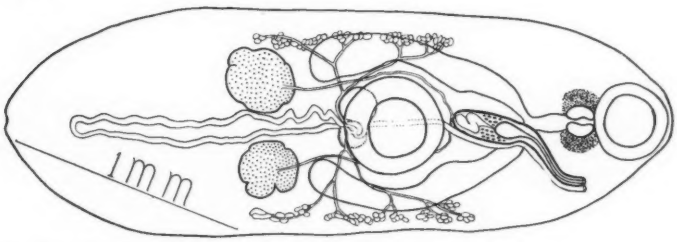

Fig. 1. *Neorenifer serpentis* sp. nov. Ventral view. A schematic and composite study.

Neorenifer serpentis sp. nov.

Description.—Body narrowly ovate, 2.8 (2.4-3.1) mm. long and 0.9 (0.7-1.2) mm. wide. Cuticle smooth. Subcuticular glands apparently lacking. Genital pores near left margin at level of pharynx. Acetabulum larger than oral sucker; ratio of their diameters 1.334. Diameter of oral sucker 0.3 (0.26-0.36) mm., of acetabulum 0.4 (0.3-0.5) mm., of pharynx 0.15 (0.13-0.18) mm. Caeca broad, extending posteriad slightly beyond acetabulum.

Testes indifferently opposite or slightly oblique with either the right or the left a little in front of the other, subequal in size, often coarsely lobed, varying in general outline from subspherical to ellipsoidal, 0.27 (0.18-0.35) mm. in diameter, at about two-thirds length of body from front end. Cirrus pouch slender, club-shaped, 0.79 (0.6-0.93) mm. long; contains cirrus, prostate glands, and S-shaped seminal vesicle; extends back to or near front margin of acetabulum. Vasa efferentia confluent at point of entry into pouch. No seminal vesicle external to pouch.

Vitellaria marginal in central third of body, not divided on either side into

* A contribution from the Zoological Laboratory, Oklahoma Agricultural and Mechanical College, prepared under the direction of R. Chester Hughes.

anterior and posterior groups by acetabulum, the follicles distinct and usually grouped into several scattering clusters. Vitelline tubules branch quasi-dichotomously, the main bifurcations of the two lateral ducts being near the median line. Ovary dextrosubmedian, dorsal to posterior side of acetabulum, 0.17 (0.11-0.23) mm. in diameter. Shell gland large and easily discernible. Uterus almost entirely in median sagittal plane, comprises a single loop reaching back almost to posterior end, the limbs being narrow and nearly straight. Distal portion of uterus not noticeably muscular. Eggs 45 x 24 μ.

Host.—*Agkistrodon piscivorous* (Lacépède 1789).

Habitat.—Lumen of oesophagus.

Locality.—Bayou Dauchite near Lewisville, Arkansas.

Type specimens.—Five specimens, mounted *in toto*, in the United States National Museum.

Discussion

Of the previously known species in the genus *Neorenifer* Byrd and Denton 1938 eleven are North American, the others being Old World forms.

The absence of cuticular spines distinguishes the new species from *N. wardi* (Byrd 1936), *N. kansensis* (Crow 1913), *N. formosum* (Nicoll 1911), *N. elongatus* (Pratt 1903), *N. zschokkei* (Volz 1899) *N. validus* (Nicoll 1911), *N. sauromates* (Poirier 1885), *N. georgianus* Byrd and Denton 1938, *N. elongatus* (Pratt 1903), *N. zschokkei* (Volz 1899), *N. validus* (Nicoll 1938, and *N. heterodontis* Byrd and Denton 1938; the sinistral position of the genital pore, from *N. orula* (Talbot 1934); and the continuous arrangement of the vitellaria on each side, from *N. acetabularis* (Crow 1913) and *N. aniarum* (Leidy 1890). For the above comparisons information on the old species was obtained from Byrd and Denton (1938).

The nearest relative of the new species appears to be *N. septicus* (MacCallum 1921)—indeed the two forms may be identical. The writers accept the opinion of Byrd and Denton that *Renifer ophiboli* MacCallum 1921 is a synonym of *N. septicus*. The two forms were taken from the same host species *Lampropeltis getulus* (Linnaeus 1766). Both were very briefly described. For the following comparisons data taken from both of MacCallum's descriptions are utilized. *N. serpentis* differs from *N. septicus* in having (1) no seminal vesicle external to the cirrus pouch such as was illustrated for *R. ophiboli*, (2) a clearly recognizable shell gland—MacCallum states that "no shell gland is seen" in *R. septicus*, (3) dichotomously branching vitelline ducts, (4) a host belonging to a different family and having different habits, and (5) a different habitat in the host—being in the lumen of the gullet rather than in lesions in the skin. The anatomical differences between the two forms are perhaps too slight to be significant, particularly in view of the casual nature of MacCallum's studies, but the distinct differences in host and habitat relationships would seem to warrant reporting our specimens, at least provisionally, as new.

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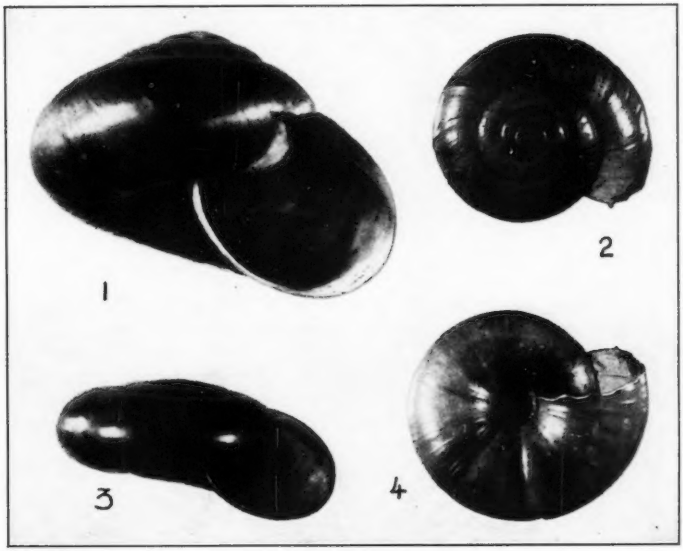
Description of New Terrestrial Gastropoda

Gordon K. MacMillan

From collections made for the Laboratory of Recent Invertebrates of the Carnegie Museum during the last few years the following terrestrial gastropoda, new to conchology, have been discovered:—

Oxychilus pulchro-striatum sp. nov.

Shell depressed, somewhat convex above and concave beneath, thin, fragile, shining, light horn-color, moderately umbilicated, and with fine, almost imperceptible striae. Whorle 5 1/3, somewhat flattened above and rounded below; body-whorl rounded. Sutures well marked and slightly impressed. Radial striae very faint and crowded together above and below; spiral striae much fainter, but more perceptible on the last two whorls. Aperture rounded lunate; peristome simple, acute, its columellar margin inserted into the center of the base and towards its columellar margin, not reflected over the umbilicus.



Figs. 1-4: 1,*O. pilsbryi globosa* MacMillan, ×3.3; 2. *Oxychilus pulchro-striatum* MacMillan, apical view, ×5.8; 3, Same, apertural view, ×5.9; 4, Same, umbilical view, ×5.7.

Umbilicus moderately large, funnel-shaped, deep, and showing all inner whorls. Greater diameter 8.5, lesser diameter 7.25, height 4.5 mm.

Type Locality.—Duquesne Bluff, Pittsburgh, Pa.

Holotype.—Carnegie Museum No. 62.32771, Section of Recent Invertebrates.

This species is closest in form to *O. rogersi,* but differs from that, and the other species of *Oxychilus,* by possessing fine and crowded radial striae and spiral striae, the latter more perceptible on the last two whorls. The columellar margin of the peristome is inserted more acutely into the base and more closely to the columellar margin of the base than in *alliarium,* but not quite as closely as in *rogersi, cellarium,* and *lucidum.* The spire of *pulchro-striatum* is not quite as high as that of *alliarium* and *cellarium,* about as high as in *rogersi,* and not depressed as in *lucidum.*

Omphalina pilsbryi globosa var. nov.

Shell very globose, thin, striated, reddish-chestnut color, umbilicated. Whorls 5½, somewhat rounded and slowly increasing, the last very much wider, and nearly flattened on the base. Sutures slightly impressed. Rib-striations prominent and regularly spaced. Spiral striae hardly perceptible and consisting of microscopic granulations; below the granulations are obsolete and the surface is smooth and polished. Apex smooth. Aperture oblique, oval; parietal wall covered with a thin callus. Peristome simple, acute, and slightly reflected over the umbilicus. Umbilicus narrow, deep. Greater diameter 16.8, lesser diameter 15.5, height 18.5 mm.

Type Locality.—Santee Canal, Berkeley County, South Carolina.

Holotype.—Carnegie Museum No. 62.32772, Section of Recent Invertebrates.

This is a narrower and more elevated shell than *O. pilsbryi.* It also differs from that species in having the growth lines developed into prominent and regularly spaced rib-striations instead of close and fine striae, and in the spiral microscopic granules being hardly perceptible instead of being prominent and plainly visible as in *pilsbryi.* The aperture of *globosa* is much more oblique and narrower than in *pilsbryi,* and the parietal wall is covered with a thin callus. Finally, the peristome is much more reflected over a narrower umbilicus than in *pilsbryi.*

CARNEGIE MUSEUM,
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Summer Movements of the Bullfrog, Rana catesbeiana Shaw, as Determined by the Jaw-Tag Method

Edward C. Raney

During the summer of 1939 the author had the good fortune to spend the period from June 15 through August 31 as a research fellow at the Edmund Niles Huyck Preserve at Rensselaerville, Albany County, New York. Conditions were ideal for the study of certain amphibians and fishes which occur in abundance and are relatively undisturbed. Among several research projects carried on was a study of the movements of frogs, especially of the bullfrog, *Rana catesbeiana*, and the green frog, *Rana clamitans*, which were common at the several ponds on the Preserve. Some 606 frogs and toads representing five species (Table 1) were marked by inserting numbered monel metal tags through the jaw (Fig. 1), and recaptures were made throughout the summer. It is planned to continue the studies over a period of several years on such problems as the rate of growth, age at maturity, maximum age, the length of the spawning period for individual frogs and additional information on daily and seasonal movements.

Methods of Marking Frogs

Previous to this study two main methods have been used to mark frogs and toads, (1) incising toes and, (2) tying a cord with tag attached around the narrowest part of the body of the animal. Hamilton (1934:88) incised toes of *Bufo americanus americanus* in studying its rate of growth. This method is one by which the toad or frog may easily be recognized again and by using various combinations, many individuals may be marked. The difficulty of bookkeeping is perhaps the biggest drawback to the method when more than a few dozen specimens are marked. Breder, Breder and Redmond (1927) marked frogs and toads by encircling the waist with a cord to which a numbered tag was tied. The main objection to this type is its lack of permanence.

TABLE 1.—The kinds and numbers of frogs and toads tagged during summer of 1939 at the Edmund Niles Huyck Preserve at Rennselaerville, Albany County, New York.

Species	Sex			Total
	Male	Female	Immature	
Rana catesbeiana	106	48	83	237
Rana clamitans	198	106	20	324
Rana pipiens pipiens	.....	.....	....	29
Rana palustris	.....	.....	....	7
Bufo americanus americanus	.....	.....	....	9
				606

Some frogs may slip the string, and when the cord was made tight to prevent escape injuries resulted. However, these healed rapidly and with no discernible ill effect on the frog. For studies carried on over short periods it is quite satisfactory and has the advantage that a number can often be read without disturbing the frog unduly. This method was used successfully by Savage (1934:55) in studying the length of time *Rana temporaria temporaria* remained in the breeding pond and in amplexus.

The jaw-tag method has been successfully used in tagging fish for several years (Shetter, 1936) but as far as the author is aware it had not hitherto been adapted to the study of frogs. It was with considerable trepidation that a start was made by tagging about 50 adult green and bullfrogs, but in several weeks the method proved to be successful in every way. The tags used were the so-called "metal strap" or "clip tags" and were inserted around the lower jaw (dentary) usually about midway between the anterior end of the snout and the point of articulation of the jaw (Fig. 1) and were locked by the use of pliers. Size number 3 proved to be best to use with large juvenile and adult bullfrogs and adult greenfrogs, while size number 2, or fingerling tags, were used on newly transformed bullfrogs and with young and juvenile greenfrogs. After three months the only noticeable effect was a slight proliferation of tissue about the dentary and in no case was any infection seen. The frogs could occasionally be seen to pull at the tag with the front feet but no serious tearing of the flesh was noted. If a slightly larger hole than was necessary was made during the insertion of the tag it was usually healed completely within two weeks. No apparent effect on the appetite was noted and food could be felt in the stomachs of the marked as well as the unmarked. The voices were not affected to any noticeable extent.

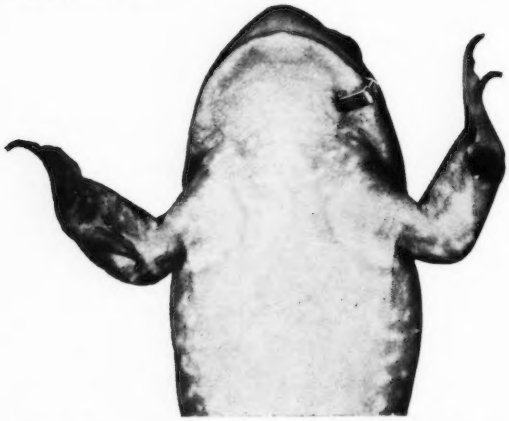

Fig. 1. A female *Rana catesbeiana*, 109 mm. long, showing the place of insertion of the tag. This frog (no. 99) was tagged on June 19 and the photograph was taken August 22.

Description of the Huyck Preserve

The Preserve is a tract of some 500 acres situated in the Helderberg Mountains at Rensselaerville, New York. The areial view shown in figure 2 illustrates the salient features of the terrain related to the problem at hand. Lincoln Pond shown near the center of figure 2 has an altitude of 1650 feet while that of Myosotis Lake which appears in the upper right hand corner of figure 2 is several feet lower. The outlet of Lincoln Pond is a small stream which flows through a thickly wooded area and into Myosotis Lake. During the drought summer of 1939 the outlet was reduced to a series of rocky woodland pools. These pools were similar to but smaller than Trout Pond which was formed by damming a small tributary stream of Lincoln Pond outlet. Trout Pond supported a large frog population until the middle of August when the water level was lowered considerably.

Lincoln Pond has an area of approximately 9 acres and is surrounded for the most part by low shrubs (largely *Alnus incana*) but with a considerable number of hemlock, *Tsuga canadensis*, at the north end. The bottom is of ooze with a shallow shelf extending almost around the pond which supports a luxurianth growth of grasses (largely *Glyceria grandis*). This grass extends out into the water from 10 to 30 feet and makes an excellent breeding habitat for both bullfrogs and green frogs. The shoreline of Myosotis Lake is rocky except for a part of the north end and the frog fauna is largely concentrated here. The area of Myosotis Lake is approximately 90 acres.

Studies of Movement

Starting the third week in June the shore line of Lincoln Pond (Fig. 2) was measured with a tapeline, and shipping tags with distances noted were placed at regular intervals. In this way individual frogs could be located quite accurately. At first the frogs were tagged in the field and were liberated at the same place. Most of the work was done at night since they were caught much more easily at this time. The following measurements were taken in mm. with the aid of dividers: 1. the length, from the anterior tip of the snout to the anus; 2. the length of the tibia. The weight to the nearest tenth of a gram was recorded. After several hundred frogs were tagged in this manner the rest were captured at night, marked the next day and liberated in the same general area in which they were taken. Each individual was given a page in a notebook and subsequent recaptures were noted.

Tagging operations were later expanded to other parts of the Preserve and some frogs were marked in Trout Pond (Fig. 1), which dried up during late August, the north end of Myosotis Pond and two small reservoirs on the property of Dr. Thomas W. Ordway. It was never possible to catch all the frogs present even in a small area and late in August many unmarked frogs were still collected and tagged.

The data on recaptures are summarized in tables 2 to 7. Although the distances in feet traveled by each individual is noted the author is well aware that a frog may have moved much farther during the time interval from the

Photo by Fairchild Aerial Surveys, Inc.

Fig. 2. An aerial view showing the northern end of the Edmund Niles Huyck Preserve at Rensselaerville, Albany County, N.Y. Lincoln Pond appears in the center of the figure and Myosotis Lake which is roughly 10 times as large may be seen at the upper right. The outlet of Lincoln Pond flows into Myosotis Lake. Trout Pond lies just to the right of the road and 200 feet from Lincoln Pond.

last capture than the data indicates. More than 65 per cent of all the bullfrogs marked were retaken at least once during the summer. This is considered high inasmuch as there was no opportunity for recapturing many specimens tagged in the latter part of August. Many tagged frogs were undoubtedly destroyed through the predations of pickerel, herons, rats, and other frogs and thus the number of those available for recapture was reduced considerably.

More males were taken with both the bullfrog and the green frog. The ratio of males to females was approximately 2 to 1 in each case.

Daily Movement

The spawning season at Lincoln Pond extended through the first three weeks in July and lasted about a week longer at the north end of Myosotis Pond. From the middle of June throughout July a good chorus of males could be heard every night. The sexually mature males would characteristically take a position from five to twenty feet from shore, among the emergent grasses where the water varied from 5 inches to two feet in depth. At this time they were much bolder than after the first of August when breeding was over. Only a few females were taken in the same area but these were invariably ready to spawn. However, most females remained close to shore under the alders. During the day both males and females were to be seen near and on shore under the shrubs. In summarizing the daily movement just before and during the breeding period it is apparent that the movements of males and females differ greatly.

Throughout August after spawning season was over there was much less tendency for the males to go out in the water at night. Both males and females were to be found close to shore and preferred those areas along the shore which were best sheltered by shrubs. Occasionally at dusk a bullfrog would be seen on land a considerable distance from water. One large male was captured at dusk along the road 350 feet from the nearest water. The ground was very dry at this time (August 9). Still later just after dark on September 22, when the air temperature was 40° F., a juvenile bullfrog was found 60 feet from the edge of the water at Lincoln Pond.

General Movement

Both during and after the spawning period the movement of individuals along the shore of the pond varied considerably as may be seen by examination of tables 2 and 3. Some adults of both sexes as well as juveniles in cases where several recaptures were made through the summer apparently moved only very short distances. Those individuals moving less than 100 feet from the point at which they were first captured are numbers 107, 113, 151, 266, 126, and 127. This appears all the more remarkable since an adult bullfrog may easily cover 50 feet in several hops after being liberated. However, most adults swim for deep water when released.

An examination of tables 2 and 3 shows that some individuals moved fairly long distances during the summer. Some of the outstanding examples are mentioned below. The greatest distance moved by any bullfrog was 3000 feet. An immature specimen (no. 729) captured in Mud Hollow Pond 5 miles away was liberated in a shallow wooded pool in Lincoln Pond outlet on July 24. On July 28 it was recaptured on the shore of Myosotis Pond at a point 3000 feet away. When taken again on September 22 it had moved but 50 feet. Another immature specimen (no. 765, table 3) moved at least 425 feet between July 31 and August 2. A male (no: 291, table 2) was liberated on the west side of Lincoln Pond on July 8 and captured on the other side of the pond July 11 having moved at least 900 feet. By July 17 he returned to the east side of the pond traveling 860 feet. An immature individual (no. 727, table 3) moved 1275 feet during the interval between July 24 and August 11. Several other specimens (nos. 106, 132, 141 and 919, table 2) also moved from one side of Lincoln Pond to the other.

Further data on the variability in the distance individuals will move were obtained from the following experiment. A number of specimens were collected from along the east side of Lincoln Pond on July 11, 1939, and liberated at one point. Table 4 shows the distances moved by the specimens which were recovered. Within a period of a month one female (no. 464, table 4) moved only 10 feet while a male (no. 447, table 4) traveled at least 465 feet.

The greatest movement occurs just after dark either during or after a rain. This generalization is well known to observers who have had occasion to be in the field at this time.

The general results presented above for the bullfrog are very similar to those obtained on the movements of the green frog by Breder, Breder and Redmond (1927) and the author.

Movement of Bullfrogs Living in Small Ponds

The tendency for bullfrogs living in small pools (200 to 500 square feet in area) along streams, as Lincoln Pond outlet, is to stay in the same pool all summer as is shown in table 5. Both *Rana catesbeiana* and *R. clamitans* spawned in these pools devoid of submerged or emergent vegetation. The pools were connected by little or no flow during the greater part of the summer and were similar to small isolated woodland ponds. If these bullfrogs changed pools the distance covered was usually less than or about 100 feet. However, one specimen (no. 902, table 5) moved up into Lincoln Pond.

A female (no. 273, table 2) and an immature specimen, (no. 762, table 3) traveled from Lincoln Pond to Lincoln Pond outlet in early August. A male (no. 105, table 2) made a similar change of position during late June or early July. There is no pronounced migration including many specimens but rather the wanderings of individuals which bring a few to the outlet stream.

Two small man-dug reservoirs on Dr. Ordway's property offered an opportunity for study in a situation which differed considerably from both

TABLE 2.—Returns on *Rana catesbeiana* tagged in Lincoln Pond during June and early July, 1939. Date tagged—×. The number on succeeding dates represents the distance traveled (in feet) from the last point of recovery. The total is the greatest distance traveled from the point of original capture. Recovered in Trout Pond—*. Recovered in Lincoln Pond outlet‡.

Tag. June

TABLE 2.—Returns on *Rana catesbeiana* tagged in Lincoln Pond during June and early July, 1939. Date tagged—×. The number on succeeding dates represents the distance traveled (in feet) from the last point of recovery. The total is the greatest distance traveled from the point of original capture. Recovered in Trout Pond—*. Recovered in Lincoln Pond outlet‡.

Tag No.	Sex	June 17	19	21	22	23	24	26	28	July 1	2	4	7	8	9	11	14	17	18	19	22	23	26	28	31	August 2	3	6	9	11	14	15	21	Sept. 28	22	Total
37	♂	×	0	10	..	..	..	..	..	5	..	85	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	90
91	♂	..	×	15	..	..	40	..	..	..	..	..	..	..	385*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	385
105	♂	..	×	20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	555‡	..	..	..	..	..	15‡	..	..	..	..	..	..	..	..	..	..	535
106	♂	..	×	..	..	..	215	20	..	..	..	..	..	..	..	800	..	..	..	..	..	..	..	..	..	..	..	..	..	0	..	..	..	..	..	800
107	♂	..	×	..	..	15	..	3	..	..	..	8	..	..	..	..	..	..	..	..	..	..	50	..	..	..	..	55	..	..	..	..	..	..	..	40
109	♂	..	×	..	..	180	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	180
110	♂	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	515	..	..	..	..	..	..	..	..	..	515
113	♂	..	×	..	..	0	..	25	..	..	..	..	..	30	..	..	..	..	..	..	..	..	30	..	..	..	..	10	..	..	..	..	..	40	..	95
128	♂	..	..	×	..	..	..	225	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	225
132	♂	..	..	×	25	..	5	..	..	..	..	..	..	20	..	..	..	25	..	35	..	..	..	..	..	..	..	..	650	..	..	..	..	..	..	685
136	♂	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
138	♂	..	..	×	..	195	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	195
141	♂	..	..	×	..	..	..	110	..	..	..	..	..	..	..	700	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	810
146	♂	..	..	..	×	..	20	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	25
151	♂	..	..	..	×	..	..	45	..	..	15	..	..	..	..	..	..	25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	45
164	♂	..	..	..	×	..	..	..	..	..	..	225	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	225
165	♂	..	..	..	×	..	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
166	♂	..	..	..	×	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5
170	♂	..	..	..	..	×	75	..	..	..	15	..	..	50	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	140
171	♂	..	..	..	..	×	..	..	..	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5
251	♂	..	..	..	..	..	..	..	..	×	..	215	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	215
257	♂	..	..	..	..	..	×	..	..	..	..	535	..	5	..	..	..	..	..	..	..	..	5	..	..	..	..	10	..	..	10	..	..	..	..	540
266	♂	..	..	..	..	..	×	..	..	..	..	50	..	..	..	..	..	..	..	..	..	..	20	..	..	..	..	..	..	..	..	..	..	5	..	50
276	♂	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	105	..	..	..	..	..	..	..	75	..	..	20	..	..	200	..	..	..	200
291	♂	..	..	..	..	..	..	..	..	..	..	..	..	×	..	900	..	860	..	..	..	..	..	..	..	..	..	..	..	..	..	..	105	..	..	900
506	♂	..	..	..	..	..	×	..	..	..	..	..	..	..	..	700*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	700
514	♂	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	160	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	160
525	♂	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	50	..	..	..	..	..	..	..	..	..	..	..	..	..	50
935	♂	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	110	..	..	110
99	♀	..	×	10	45	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	15	..	75	150
102	♀	..	×	5	..	..	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5
108	♀	..	×	..	..	40	10	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	50
114	♀	..	×	..	..	5	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5
140	♀	..	..	×	..	..	10	..	..	..	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10
260	♀	..	..	..	..	..	×	..	30	..	..	35	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	30
273	♀	..	..	..	..	..	..	..	..	..	..	..	×	..	..	190	..	240	..	..	40	..	290	..	..	210	..	5	45	170	..	70‡	..	150	..	355
285	♀	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5
89	im.	..	×	..	5	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10
126	im.	..	..	×	5	..	..	..	..	..	..	15	..	..	..	..	..	..	..	..	..	..	..	40	..	..	25	..	..	40	..	..	20	..	..	65
127	im.	..	..	×	..	..	10	..	..	..	..	..	..	..	..	..	..	5	..	..	..	..	..	..	5	5	..	15	..	..	..	..	..	..	..	40
919	im.	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	800	..	..	..	..	..	..	800

Lincoln Pond and Trout Pond. These pools have been designated as Upper and Lower Ordway Reservoirs and each had an area of about 1000 square feet of water surface in July. They are separated from each other by an earthen bank about 6 feet high and 20 feet wide. The Upper Reservoir had been dug some 7 years before and had reached a point where there was considerable aquatic vegetation present both of a submerged and an emergent type. Invertebrates were abundant. The Lower Reservoir was but two years old, had practically no vegetation and the water was slightly turbid most of the time. The nearest satisfactory habitat for bullfrogs was Myosotis Lake, close to one-fourth of a mile away.

The Upper Reservoir had a very large frog fauna and 45 bullfrogs were captured during the summer. A considerable number of *Rana clamitans* and *Rana pipiens pipiens* were also taken. Only 13 bullfrogs were captured in the Lower Reservoir. There were 31 male, 6 female and 21 immature bullfrogs in both reservoirs. A few more than half of these were recovered during the summer (Table 6).

Those species in the Lower Reservoir tended to remain throughout the

TABLE 3.—Returns on *Rana catesbeiana* tagged in Lincoln Pond during the latter part of July and through August, 1939. Date tagged—×. The number on succeeding dates represents the distance traveled (in feet) from the last point of recovery. The total is the greatest distance traveled from the point of original capture. Lincoln Pond outlet—‡.

Tag No.	SEX	July									August							SEPT.	TOTAL
		16	17	18	19	23	24	26	28	31	2	6	11	14	15	21	28	22	
524	♂					×											10		10
509	♀		×	10						400			60						400
510	♀		×								100	400							400
513	♀		×								20								20
515	♀		×								100							0	100
523	♀				×			15											15
647	im.	×	30					15											45
648	im.	×									30								30
671	im.		×											20					20
727	im.						×						1275						1275
748	im.									×270			0						270
761	im.									×			120						120
762	im.									×					135‡				135
763	im.									×			40						40
764	im.									×			20				0		20
765	im.									×	425								425
766	im.									×						420	0		420
797	im.										×						40		40
819	im.													×			5	10	15
820	im.													×			190		190
821	im.													×		0	0	5	5
925	im.													×		185			185
934	im.															×		375	375
936	im.																×	25	25
943	im.																×	550	550
945	im.																×	40	40

summer while some from the Upper Reservoir moved during late August and September when the water level became lowered, and some laborers were excavating at the upper end. After the frogs in both reservoirs were disturbed several times it was exceedingly difficult to make recaptures.

Homing

On June 9, three males, one female and 27 immature bullfrogs were captured in Trout Pond and liberated in Lincoln Pond at a point 240 feet away. Both ponds had a large bullfrog population and could probably be considered equally desirable habitats. Two males and 17 immatures were recaptured (table 7). Of those recovered two immatures (nos. 310 and 323) made their way back to Trout Pond. Later in the summer these two individuals moved to Lincoln Pond when Trout Pond became very low after a prolonged drought.

Three other immatures tagged later in Trout Pond were recovered in Lincoln Pond in August and September. Two males (nos. 91 and 506, table 2) captured and tagged in Lincoln Pond were subsequently recaptured in Trout Pond.

It is difficult to generalize from these meager returns but the evidence points to a lack of a homing tendency in these bullfrogs. While it is true

TABLE 4.—Returns on *Rana catesbeiana* taken along the east shore of Lincoln Pond and liberated July 11, 1939, at one spot on the same side of the pond. The number on succeeding dates represents the distance traveled (in feet) from the point of last recovery. The total is the greatest distance traveled from the point at which all those in this table were liberated.

Tag No.	Sex	July 17	August 11	August 14	Sept. 22	Total
411	♂	750				750
447	♂		465			465
468	♂		290			290
470	♂		220			220
472	♂		400			400
438	♀		245			245
442	♀		255			255
464	♀		10			10
465	♀		165			165
471	♀		10	10	300	300
429	im.		450			450
432	im.		130	20		130
443	im.				650	650
444	im.		420			420
445	im.				210	210
446	im.		290			290
459	im.		240			240
467	im.		160			160
469	im.		380			380
605	im.		300			300

TABLE 5.—Returns on *Rana catesbeiana* tagged in isolated pools in the stream bed of Lincoln Pond outlet during 1939. Date tagged—×. The number on succeeding dates represents the distance traveled (in feet) from the last point of recovery. The total is the greatest distance moved from the point of original capture.

Tag No.	Sex	June	July				August			Sept.	Total	
		24	5	18	28	31	6	15	28	22		
189	♀	×				20		0	5	20	20	Same pool
517	♀			×		15					15	Same pool
518	♀			×	10				5		15	Same pool
268	im.		×		0			0			0	Same pool
550	im.				×				70		70	Moved upstream one pool
674	im.			×					0		0	Same pool
680	im.			×		15					15	Same pool
681	im.			×					5	20	15	Same pool
733	im.			×			700				700	Moved to Trout Pond
752	im.				×				55		55	Moved upstream one pool
754	im.				×				25		25	Same pool
755	im				×				5		5	Same pool
771	im.					×			110		110	Moved upstream one pool
825	im							×	30		30	Same pool
902	im					×			175		175	Moved up into Lincoln Pond

that one frog (number 310, table 7) returned to Trout Pond within 5 days after he was liberated in Lincoln Pond 240 feet distant and another (no. 323, table 7) returned sometime between 17 and 28 days afterwards, 17 individuals did not return as far as we were able to determine.

However, a remarkable instance of homing in *Rana catesbeiana* is reported by McAtee (1921:39). A bullfrog with a front foot missing became quite tame so that it could be caught by hand at any time. After being removed "some distance down an arm of the lake" it returned by the next morning. A second time the frog was taken to a small spring a quarter of a mile overland but was back home the second morning.

Breder, Breder and Redmond (1927:209) reported a case of two specimens of *Rana clamitans* returning to a spring from which they had been taken. In

TABLE 6.—Returns on *Rana catesbeiana* tagged in Ordway's Reservoirs during July. Note that some of the frogs from the Upper Reservoir moved to the Lower Reservoir. This movement occurred largely in August when the water level of the former dropped considerably. Some additional excavation of the Upper Reservoir was done at this time and this may have been a factor influencing movement. The frogs in the Lower Reservoir did not move. Date tagged—×. Date recovered—*.

		Upper Reservoir				Lower Reservoir				
Tag		July			August	July			August	Sept.
No.	Sex	10	18	26	15	10	18	26	15	22
338	♂	×	*							
339	♂	×					*	*	*	*
340	♂	×							*	
341	♂	×	*						*	
345	♂	×	*		*					
347	♂	×			*					
356	♂	×	*							
361	♂	×	*							
371	♂	×	*	*					*	
372	♂	×	*		*					
373	♂	×	*							
374	♂	×	*	*						
375	♂	×		*						
376	♂	×			*					
522	♂		×		*					*
546	♂		×						*	
357	♀	×	*		*					*
377	♀	×		*						
379	im.	×		*						
380	im.	×	*							
688	im.		×	*						
691	im.		×	*	*					
390	♂					×	*		*	*
391	♂					×	*	*	*	*
393	♂					×	*			
394	♂					×		*	*	
392	♀					×	*	*		
405	im.					×	*	*	*	*
406	im.					×	*		*	*
407	im.					×			*	

this instance on their return journey they had to cross a brook which had proved to be a good habitat for this species. They also found (1927:227) that *Bufo fowleri* had a well developed homing instinct when in voice.

Summary

1. The jaw-tag method of marking frogs proved to be entirely satisfactory and is superior to the other methods of tagging used in the past especially for long term studies.

2. Six hundred and six individuals of 5 species of frogs and toads were tagged between June 15 and August 31, 1939, at the Edmund Niles Huyck Preserve, Rensselaerville, Albany County, New York. Of this number there were 237 bullfrogs and 324 green frogs. In both species the sex ratio was approximately 2 to 1 (males to females).

3. Slightly more than 65 per cent of all the bullfrogs marked were recaptured at least once during the summer. This percentage is considered high inasmuch as there was no opportunity for recapturing many tagged in the latter part of August and the predations of herons, pickerel, rats and other frogs reduced the number of those available for recapture considerably.

4. Just before and during the spawning season of the bullfrog the behavior of males and females is quite different. During the daylight hours both sexes are usually to be found along the water's edge under the alders and other shrubs. At night the males move out into the shallow water among the

TABLE 7.—Returns on *Rana catesbeiana* taken from Trout Pond on July 9, 1939 and liberated in Lincoln Pond at a point 240 feet away. The number on succeeding dates represents the distance traveled (in feet) from the last point of recovery. The total is the greatest distance traveled from the point of liberation in Lincoln Pond. A return to Trout Pond—*. A return to Lincoln Pond—†.

Tag		July				August						Sept.	
No.	Sex	14	17	26	31	2	6	14	15	21	28	22	Total
300	♂			85			75			5		25	190
306	♂		85	15									100
294	im.		35										35
296	im.		40		30	0	0			15	20		85
297	im.			50									50
299	im.		35										35
301	im.			60	5	0				5			60
304	im.			40		5	10			20		30	65
308	im.		40										40
309	im.		35	0	5	0	0				5	20	55
310	im.	245*						230†	5				245
311	im.			70	15							130	85
314	im.		55	5	40						165		265
317	im.			5		10	0			20	0		35
319	im.		35										35
320	im.			25									25
323	im.			35			280*				360†	10	245
325	im.			20									20
331	im.			60			50						110

emergent grasses, take positions and give their typical bass call notes. The females, however, stay close to the shore line unless they are ripe. When ready to spawn they make their way to the area occupied by the males.

5. After the height of the breeding season is past the males tend to stay closer to shore both during the day and night although an occasional individual may be found 20 to 30 feet from shore.

6. Throughout the summer there is great variation in the distance individuals of both sex as well as juveniles will move. Some are relatively stable, moving only 100 feet or less throughout the summer, while others move long distances (up to 3000 feet). These movements did not appear to be correlated with spawning, food getting, changes in temperature, or other tangible factors.

7. Those frogs which do move usually travel after dark during or after a rain.

8. Bullfrogs living in small pools either along stream beds or isolated ponds tend to remain in these pools all summer if the water level is maintained.

9. Little evidence was found of well developed homing behavior.

ACKNOWLEDGEMENT

The author is indebted to Mrs. Edmund Niles Huyck who furnished facilities and equipment for the studies and to Mr. Francis Huyck Eldridge, treasurer of the Preserve, for many kindnesses. Dr. W. J. Hamilton, Jr., Dr. G. K. Noble and Dr. Thomas W. Ordway, of the Biological Advisory Committee of the Preserve, made valuable suggestions and cooperated in every way throughout the summer. Mr. Thomas W. Ordway, Jr. assisted in the field work as did Mr. Ernest A. Lachner who accompanied the author on an overnight trip to the Preserve on September 22 when an attempt was made to ascertain if any of the frogs had as yet gone into hibernation. My wife, Charlotte E. Raney, was a constant and indispensable assistant during the entire summer both with the field and laboratory work. Professor A. H. Wright read the manuscript and made several suggestions for its betterment.

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Skull of Fossil Cetotherean Whale, Siphonocetus priscus,

from the Miocene of the Chesapeake Bay Region

Arthur R. Barwick

During May, 1938, while on a trip to the Calvert Cliffs on the western shore of Chesapeake Bay, the author and a party of students discovered the occipital portion of a cetothere skull protruding from the cliff about twelve feet above tide-level. The location was about half a mile south of the mouth of Parker Creek, and in Zone 13 of the Miocene series. The skull was removed in two pieces together with about a hundred pounds of loosely adhering clay marl and taken to the Geological Laboratories of the Catholic University of America where the matrix was carefully removed and the fossil bone strengthened and restored.

The remains consisted of the hinder half of the skull and the symphysial portion of the right mandibular ramus. The former measured 645 mm. long, 420 mm. wide, and had a maximum thickness of 200 mm. The whole was eventually mounted upon a plaster base from which it could be readily removed.

The mandibular fragment may be described as follows. It measures 330 mm. from the symphysial end to the point of fracture which is clean and sharp, and has a diameter of 65 mm. In cross-section it is wedged-shaped with the greatest thickness of 35 mm. in the upper third; the lower two-thirds thinning evenly to about 5 mm. The inferior, internal surface, in the region of the symphysis, is sharply depressed to about half the thickness of the upper portion giving a rounded, steplike profile (Fig. D). In all essential respects it showed a marked resemblance to the mandible described by the author recently[1] under the name of *Siphonocetus priscus* which was 1150 mm. long, 70 mm. wide, and had a maximum thickness of 40 mm. Assuming the two identical, and noting that the thickness of the mandibular fragment in question is about 10% less than the complete jaw referred to above, the estimated length of the entire mandible should be about 1000 mm. Such a lower jaw would just about fit the more mature skull of this fossil species at the U. S. National Museum (No. 10677) which, in all respects is about 10% larger than the specimen described here. A careful restoration of the rostrum of the skull, in proper ratio to the more complete specimen at the National Museum, makes the more probable length of the entire jaw only 945 mm. In a recent talk with Dr. Kellogg[2] who is tabulating the dimensions of many of the fossil jaws

1 Proc. Biol. Soc. Washington **51**:121-122, 1938.

2 Dr. Remington Kellogg, Associate Curator of Mammalogy, U. S. National Museum, Washington, D. C.

of this type, I have been assured that this is no severe difficulty, as the ratio of width to length often varies between fairly large limits even in the same species.

The taper of the external border of the rostral portion of the maxillaries, so far as they have been preserved, is about 7° to the medial line. In the living gray whale, *Rhachianectes glaucus,* which resembles the skull more in outline than that of the Greenland whale, *Balaena,* the corresponding rostral taper is 9°. It is interesting to note that Lydekker[3] states that the gray whale is "in all probability a very ancient, generalized type" which would tend to account for its greater similarity to the fossil whale in question. I do not think that the fossil whale described in this paper exceeded 25 feet in length which is about half that of the existing gray whale.

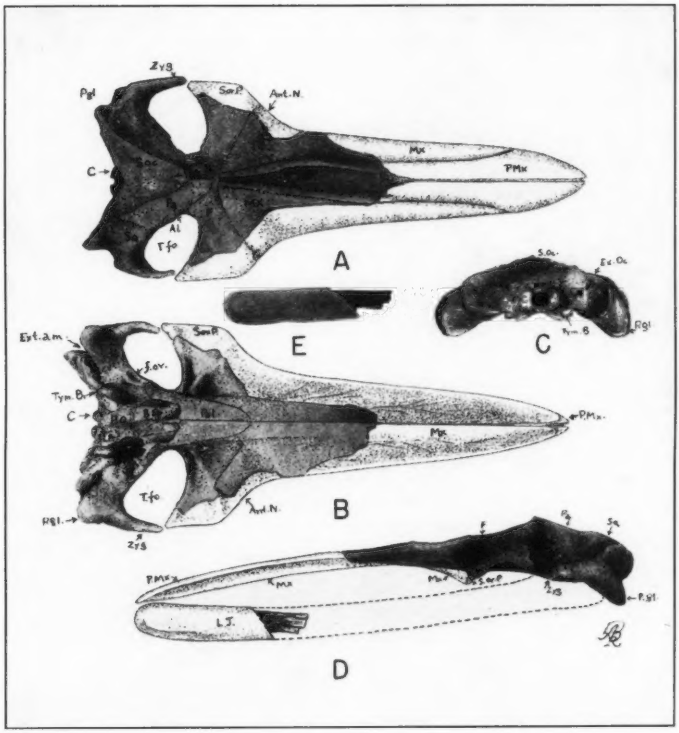
The Skull.—The skull shows only a moderate amount of telescoping and is distinctly cetotherean in structure. The rostrum is missing beyond 6 inches from posterior limits of the blow-hole so that, by the above approximation, only about half its entire length is preserved. Part of the unbroken margin of the left maxillary has been preserved and from this it is estimated that the skull must have had an overall length of about 1000 mm. Its width, at the center of the orbits is 350 mm. but the bone here has obviously been partially broken away so it is increased, in the restoration, to 394 mm. to agree with the type. Across the zygomatic processes of the squamosals, the width is 420 mm. The maxillaries are roughly triangular with a 7° taper in the preserved portion. The nasals are missing but, by the shape of the blow-hole, it is estimated that they would probably extend to this point giving them an approximate length of 100 mm. The proximal portion of the premaxillaries, emarginating the blow-hole, are in place but the one on the right side is somewhat crushed in. It is reasonable to assume that the undeformed blow-hole had a maximum width of 60 mm. In the vicinity of the orbits, the face broadens sharply bringing to the surface of the skull the supra-orbital processes of the frontals.

The temporal fossae are ovoid with the narrower portion pointing forwards and inwards. The inner surfaces, bounded by the squamosals and parietals, are quite straight compared to the exterior lateral margins. The temporal fossae are longer antero-posteriorly (165 mm.) than they are laterally (105 mm.). The parietals rise sheerly from the floor of the skull at an angle of about 70° and meet along the median-dorsal line of the skull in a sharp edge. They seem to be separated from the premaxillaries and the maxillaries by the frontals which are exposed for a distance of not more than 10 mm. at this point. The parietals make sharp contact dorsally with the triangular supra-occipital and extend posteriorly to about the middle of the temporal fossae where they are joined by the squamosals that sheath the hinder portion of the cranium. The squamosals are large, thick bones which constitute the major portion of the postero-lateral area of the skull. They meet the supra-occipital in a sharp ridge which is a continuation of that made by the supra-occipital and the parietals. In the region of the occipital condyles, they are greatly

3 Lydekker, R.: Natural History, III, p. 13; Merrill & Baker.

thickened and swing outward and forward to form the zygomatic processes. Due to fracture, it is not definitely inferable how close the zygomatic processes approximate the posterior angle of the supra-orbital processes of the frontals but they appear to have approached quite closely. Pointing downward and outward are the heavy post-glenoid processes of the squamosals which are trapezoidal in outline. Between the post-glenoid processes and the corresponding exoccipital processes of the supra-occipital on each side, there is a distinct furrow for the external auditory meatus averaging over 10 mm. in width and 20 mm. deep. The supra-occipital is roughly triangular. It forms a bluntly pointed flat roof overlying the medial ridge formed by the junction of the parietals, and slopes downward posteriorly at an angle of about 15° toward the occipital condyles and outward to the exoccipital processes which are sharply truncated (almost at right angles) where they overlap the posterior edges of the squamosals. The supra-occipital becomes progressively concave as it widens posteriorly, having a depth of 30 mm. for 160 mm. of width directly above the occipital condyles.

The median trough of the dorsal surface of the rostrum is floored by the vomer and emarginated by the premaxillaries. The maxillaries meet ventrally below the vomer, on the under side of the skull, and extend posteriorly to a point on the ventral axis of the rostrum about level with the antorbital notches where they articulate with the palatines. Posterior to this point the maxillaries flare laterally to underlie the supra-orbital processes of the frontals. The anterior sutures between the palatines and the maxillaries are not clearly delineated but these bones floor the posterior portion of the ventral axis of the skull and should extend backwards to the region of the foramen ovale which is preserved on the right side. Owing to their thinness, the posterior third of each palatine has been broken away and lost. Their greatest width is estimated around 60 mm. and greatest length over 200 mm. The roof of the posterior narial cavities is covered by the vomer which bears a strong median keel which sheathes the basisphenoid posteriorly. The anterior limits of the basisphenoid cannot be seen but the visible portion measures 64 mm. in width, tapering a little posteriorly where it joins the basioccipital. The latter is roughly trapezoidal in shape with the smaller part of the wedge pointing forward. The lateral protuberances of the basioccipital are flat and ovoid; about 30 mm. by 40 mm. The basioccipitaal articulates posteriorly with the exoccipitals from which the occipital condyles have been broken off. These, however, have been restored in the illustrations. Both tympanic bullae have been found. They occupy distinct pockets bounded internally by the basioccipital and externally by the periotics and the internal edges of the squamosals. The tympanic bullae are shaped like a loosely closed fist with an antero-posterior diameter of 55 mm. and a width and thickness of about 28 mm. These dimensions are roughly about one-fourth those of the corresponding organ in the modern Right Whale *(Balaena)* which attains a length of forty-five to fifty feet.



Siphonocetus priscus: 1/14 Natural Size. A, dorsal aspect; B, ventral aspect; C, posterior aspect; D, profile with mandibular fragment in place; E, fragment of right mandible.

Abbreviations: Al. alisphenoid; Ant.N. antorbital notch of maxillary; B.O. Basi-occipital; B.Sp. basi-sphenoid; C. occipital condyle; Ex.O. ex-occipital; Ext.a.m. channel for external auditory meatus; F. frontal; f.ov. foramen ovale; L.J. lower jaw; L.pr. lateral process of basi-occipital; Mx. maxillary; Pa. parietal; Pal. palatine; P.gl. post-glenoid process; P.Mx. premaxillary; S.oc. supra-occiptal; S.or.pr. supra-orbital process of the frontal; Sq. squamosal; T.fo. temporal fossa; Tym.B. tympanic bulla; Zyg. zygomatic process of squamosal.

DIMENSIONS OF SKULL IN MILLIMETERS

1. Length of preserved portion of skull	645 mm.
2. Estimated entire length of restored skull	1025 mm.
3. Distance between jaw socket and antorbital notches	290 mm.
4. Restored length of entire rostrum from middle of orbits	745 mm.
5. Width of skull at zygomatic processes	420 mm.
6. Width of skull at middle of orbits, as measured	350 mm.
7. Width of skull at middle of orbits, as restored	394 mm.
8. Width of mandibular fragment	65 mm.
9. Restored length of mandible	945 mm.

Photographs of the actual remains were printed to scale, pasted on bristle-board, and the reconstructed portions drawn in with India ink to agree with comparative dimensions of the more complete skull at the National Museum (No. 10677). The fragment of the jaw was then reduced in scale photographically to agree with the skull proper and placed in true position in Fig. D. The restored dorsal aspect is shown in Fig. A; the ventral aspect in Fig. B; and the back view in Fig. C. An actual picture of the mandibular fragment appears in Fig. E. The occipital condyles, missing on the original specimen, are drawn in on the retouched protographs of Figs. A, B, and C.

The skull described above is distinctly cetotherean in type and appears, from the general anatomy of its facial parts and from the fragment of the right mandible that has been preserved, to be correctly assigned to the fossil Miocene species, *Siphonocetus priscus*. A somewhat larger and more mature specimen of this species is represented by the United States National Museum specimen, No. 10677. The remains, as mounted, will be turned over to the United States National Museum where it will be available for future reference.

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Notes and Discussion

A SECOND SPECIMEN OF INDIANA BEAR SKULL

The only specimen of Black Bear previously known from Indiana is in the possession of Mr. J. W. Quick of Brookville. It was found in a hollow tree in Franklin County in 1882 (Amer. Midl. Natur. 17(1):351, 1936).

Last autumn Professor H. C. Nester, of Butler University, said that he had recently received for identification a bear skull from Mr. Lowell Barker, Bloomfield, Greene County, Indiana. Mr. Barker told him the skull was found in an old coal mine working. Through Professor Nester's kindness Mr. Barker lent me the skull for examination.

It is in excellent condition considering the length of time that Black Bears have been extinct in Indiana, probably at least 60 years. It appears to be an old male with the molar teeth considerably worn, a much older specimen than Mr. Quick's. The specimen gives these measurements: Length from front of foramen magnum to the front of the skull, 280 mm.; zygomatic width, 194 (estimated from the perfect side); mastoid width, 145; width at alveoli of canines, 75; maxillary tooth row (not including the canines), 80; palate to front of incisors, 152; maximum width at crown of molar teeth, 78; postorbital width, 120; postorbital constrictiion, 65; palatal notch to notch between condyles, 131; height of skull including molars, 123; anteroposterior length of last upper molar (m2), crown 29; width of same tooth, 13 (the maxillary teeth on each side are essentially the same size); next to last upper molar (m1), 19 x 12; small triangular tooth just in front (pm4), 12 x 8; canines, 25 anteroposteriorly, 12 laterally.—M. W. Lyon, Jr.

Book Reviews

Liverworts of Southern Michigan. By William Campbell Steere. Cranbrook Institute of Science, Bloomfield Hills, Mich., Bulletin 17. January 1940. 97 pp., 22 pl., frontispiece. Paper bound $0.50, cloth $1.00.

"The purpose of this small volume," as the author states in the introduction, "is to make possible the recognition and identification of Michigan liverworts in the field or in the laboratory, without the necessity of using a microscope." This handbook which might appropriately be called Liverworts with a Hand-Lens, "is designed for those who wish to learn the identity and to recognize at sight the commoner members of an interesting but often overlooked group of plants." Although the character of the work is necessarily taxonomic the author has by no means neglected other aspects of bryological work. Several chapters are devoted to the historical background of the group, its general characters, structure and reproduction, habitat, hints as to what to collect, methods for the preservation and permanent mounting of the material, equipment needed for collecting and identification, and the use of keys. The volume contains descriptions of 40 genera and 52 species of the most common liverworts of the region. The descriptions are concise but clear, setting forth the outstanding characters of each form presented. Every species described, with the exception of *Riccia fluitans* L. and *Preissia quadrata*

(Scop.) Nees, is figured in more or less detail. Plates 1-3 are from original photographs by Dr. E. B. Mains and the remainder of the plates from original drawings by Miss O. Embrey. Keys for the determination of the species are everywhere inserted.

Although the work is intended to be primarily for local use, yet because of the occurrence of identical forms in many other regions throughout the United States it necessarily has a wider application than its title would indicate. The book also contains a glossary and a generic index with the name of the species under each genus.

It is a pleasure to recommend the book to everyone interested in this group of plants.

—F. M. PAGÁN, *Dept of Botany, Univ. of Michigan.*

AN INTRODUCTION TO GENETICS. By A. H. Sturtevant and G. W. Beadle. W. B. Saunders Company, Philadelphia, 1939. 391 pp., 126 figs., colored frontispiece and 3 pls. $3.25.

Despite its rather recent origin genetics is customarily approached through an account of its history. Contrary to this practice, the authors of this "Introduction" adopt a different arrangement. They believe that genetics is "a mathematically formulated subject that is logically complete and self-contained." In keeping with their aim to present "a natural order," the authors begin with the phenomena of sex inheritance and conclude the book with an historical record of the outstanding discoveries. As a result "the book should be read from the beginning, like a textbook of mathematics or physics, rather than in an arbitrarily chosen order. . . ."

Recent genetic information is well represented with Maize and Drosophila as the two best known organisms to demonstrate principles which can be applied directly to the problems appended to each chapter. Here, too, can be found selected references to acquaint the student with the most important literature. In addition, numerous original diagrams and illustrations, which reveal great care on part of the authors in their preparation and selection, assist the reader in grasping the essentials.

Admittedly written for students who have had some fundamental training in biology, the new "Introduction" is an eminently sound text which transgresses definitely the elementary level. This may limit somewhat its circulation but can in no way detract from the value of the book.—TH. JUST.

SPRING FLORA OF MISSOURI. By Julian A. Steyermark. Missouri Botanical Garden and Field Museum of Natural History, St. Louis, 1940. viii + 582 pp., map, 163 pls., 444 figs. $3.00.

In comparison with available books of similar nature, the "Spring Flora of Missouri" stands out at once because of its size, its numerous illustrations, and the large number of species included. Apparently, the author has spared neither time nor effort in its preparation and one almost regrets that the book was not expanded into a "Flora of Missouri."

Since the "book is intended for use of everyone interested in plants, particularly the beginner," its descriptions are as non-technical as possible and its keys are based largely on vegetative characters. Common names precede the scientific ones, the meanings of which are explained in suitable indices.

June 1 was chosen as the time limit for flowering and the inclusion of a species. Despite this limitation and the exclusion of such difficult and specialized groups as the grasses, sedges, and rushes, about 1400 species are treated and obviously make the book useful beyond the boundaries of Missouri.

The numerous illustrations, habit sketches as well as diagrams, were prepared by a staff of artists and the author. Their uniformity and general excellence are likely to contribute materially to the popularity of the book.

Fortunately, the names used are those gleaned from the most recent revisions and monographs. This feature, as well as the many personal observations recorded by the author, make the book valuable to the professional botanist and at the same time assure the beginner of scientific accuracy. In short, the book is the best "Spring Flora" available at present in the United States.—TH. JUST.

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